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(71) Applicant *(for all designated States except US)*: NITROMED, INC. [US/US]; 801 Albany Street, Boston, MA 02118 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: GARVEY, David, S. [US/US]; 10 Ground Hill Drive, Dover, MA 02030 (US). SCHROEDER, Joseph, D. [US/US]; 229 Hierley Street, Cambridge, MA 02141 (US). SAENZ DE TEJADA, Inigo [US/ES]; Francisco Sanfiz, N-07, Aravaca, E-08023 Madrid (ES).

(74) Agents: HERRON, Charles, J. et al.; Carella, Byrne, Bain, Gilfillan, Cecchi, Stewart & Olstein, 6 Becker Farm Road, Roseland, NJ 07068 (US).

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(54) Title: NITROSATED AND NITROSYLATED α-ADRENERGIC RECEPTOR ANTAGONIST COMPOUNDS, COMPOSITIONS AND THEIR USES

(57) Abstract

Disclosed are nitrosated and nitrosylated α-adrenergic receptor antagonists, compositions of an α-adrenergic receptor antagonist (α-antagonist), which can optionally be substituted with at least one NO or NO_2 moiety, and a compound that donates, transfers or releases nitric oxide as a charged species, i.e., nitrosonium (NO^+) or nitroxyl (NO^-), or as the neutral species, nitric oxide ($NO^\cdot$); and uses for each of them in treating human impotence or erectile dysfunction.

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NITROSATED AND NITROSYLATED α-ADRENERGIC RECEPTOR ANTAGONIST COMPOUNDS, COMPOSITIONS AND THEIR USES

This application is a continuation-in-part of U.S. patent application serial no. 08/595,732 filed February 2, 1996 (copending).

This invention generally relates to α–adrenergic receptor antagonists, compositions containing them and their use in treating human male impotence.

Erectile dysfunction or impotence is a widespread disorder that is thought to affect about ten to fifeteen percent of adult men. Some pharmacological methods of treatment are available. Such methods, however, have not proven to be highly satisfactory or without potentially severe side-effects. Papaverine is now widely used to treat impotence, although papaverine is ineffective in overcoming impotence due, at least in part, to severe atherosclerosis. Papaverine is effective in cases where the dysfunction is psychogenic or neurogenic and severe atherosclerosis is not involved. Injection of papaverine, a smooth muscle relaxant, or phenoxybenzamine, a non-specific antagonist and hypotensive, into a corpus cavernosum has been found to cause an erection sufficient for vaginal penetration however, these treatments are not without the serious and often painful side effect of priapisim. Also, in cases where severe atherosclerosis is not a cause of the dysfunction, intracavernosal injection of phentolamine, an α–adrenergic antagonist, is used. As an alternative or, in some cases, an adjunct to α–adrenergic blockade, prostaglandin E1 (PGE1) has been administered

via intracavernosal injection. A major side effect frequently associated with intracorprally delivered PGE1 is penile pain and burning. Thus, there is a need for treatments of human male impotence without the undesirable side effects of those agents currently used.

Nitric oxide (NO) and NO donors have been recognized as mediators of nonvascular smooth muscle relaxation. This effect includes the dilation of the corpus cavernosum smooth muscle, an event involved in the penile erection process. However, the effects of such compounds together with α–adrenergic receptor antagonists or the modifications of α–adrenergic receptor antagonists to be directly or indirectly linked with a nitric oxide adduct have not been investigated.

In the process of arriving at the present invention it was recognized that the risk of toxicities and adverse effects that are associated with high doses of α–adrenergic receptor antagonists can be avoided by the use of such α–adrenergic receptor antagonists when nitrosated or nitrosylated or when administered in conjunction with compounds that donate, release or transfer nitric oxide. Such toxicities and adverse effects include postural hypotension, reflex tachycardia and other arrythmias, syncope and, with respect to the ergot alkaloids, nausea and vomiting and, upon prolonged or excessive administration, vascular insufficiency and gangrene of the extremities. The α–adrenergic receptor antagonists and compounds that donate, release or transfer nitric oxide work together to permit the same efficacy with lower doses of the α–adrenergic receptor antagonists.

Accordingly, in one aspect the invention provides novel nitrosated and nitrosylated α–adrenergic receptor antagonists (NO_n-α–antagonists) wherein n is 1 or 2. The α–adrenergic antagonist can be nitrosylated or nitrosated through sites such as oxygen (hydroxyl condensation), sulfur (sulfhydryl condensation), carbon and nitrogen. The invention also provides compositions comprising such compounds in a pharmaceutically acceptable carrier.

In another aspect the invention provides a composition comprising a therapeutically effective amount of an α–adrenergic receptor antagonist (α–antagonist), which can optionally be substituted with at least one NO or NO_2 moiety, and a

compound that donates, transfers or releases nitric oxide as a charged species, *i.e.*, nitrosonium (NO^+) or nitroxyl (NO^-), or as the neutral species, nitric oxide (NO•), preferably in a one to ten fold molar excess. The invention also provides compositions comprising such compounds in a pharmaceutically acceptable carrier. The α–adrenergic receptor antagonist used in the composition can be those described above and others which are known and can alternatively be such α–antagonists which have been nitrosated or nitrosylated in accordance with the invention.

In another aspect, the invention provides a method for treating male impotence in humans which comprises administering to an individual in need thereof a therapeutically effective amount of a nitrosated or nitrosylated α–antagonist.

In another aspect, the invention provides a method for treating male impotence in humans which comprises administering to an individual in need thereof a composition comprising a therapeutically effective amount of an α–antagonist which can optionally be substituted with at least one NO or NO_2 moiety, and a compound that donates, transfers or releases nitric oxide as a charged species, *i.e.*, nitrosonium (NO^+) or nitroxyl (NO^-), or as the neutral species, nitric oxide (NO•). The α–antagonist or α–antagonist directly or indirectly linked to at least one NO or NO_2 group, and nitric oxide donor can be administered separately or as components of the same composition.

Figure 1 shows the percent peak erectile response *in vivo* compared to that produced by 150 µl of papaverine/phent amine/PGE1 (pap/phent/PGE1) (30 mg/ml: 1 mg/ml: 10 µg/ml) in the anesthetized rabbit following the intracavernosal injection of 150 µl of yohimbine (150 µg, 500 µg), Example 1 (500 µg), and a combination of yohimbine (150 µg) and Example 1 (500 µg). The ordinate is the percent response of intracavernosal pressure relative to that produced by pap/phent/PGE1 and the abscissa indicates the various drugs given.

Figure 2 shows the duration of the erectile response *in vivo* in the anesthetized rabbit upon intracavernosal administration of yohimbine (150 µg, 500 µg), Example 1 (500 µg), and a combination of yohimbine (150 µg) and Example 1 (500 µg). The ordinate indicates the various drugs given and the abscissa is the duration in minutes.

Figure 3 shows the percent peak erectile response *in vivo* compared to that produced by 150 µl of pap/phent/PGE1 (30 mg/ml: 1 mg/ml: 10 µg/ml) in the anesthetized rabbit following the intracavernosal injection of yohimbine (150 µg. 500 µg and 1 mg) and Example 2 (500 µg, 1 mg). The ordinate is the percent response of intracavernosal pressure relative to that produced by pap/phent/PGE1 and the abscissa indicates the various doses of yohimbine and Example 2 given.

Figure 4 shows the duration of the erectile response *in vivo* in the anesthetized rabbit upon intracavernosal administration of yohimbine (150 µg. 500 µg and 1 mg) and Example 2 (500 µg and 1 mg). The ordinate indicates the various doses of yohimbine and Example 2 given and the abscissa is the duration in minutes.

Figure 5 compares the effects of intracavernosal injections of Example 2 (500 µg) and the standard mixture of pap/phent/PGE1 on systemic blood pressure in the anesthetized rabbit.

Figure 6 shows the percent peak erectile response *in vivo* compared to that produced by 150 µl of pap/phent/PGE1 (30 mg/ml: 1 mg/ml: 10 µg/ml) in the anesthetized rabbit following the intracavernosal injection of moxisylyte (1 mg) and Example 6 (1 mg). The ordinate is the percent response of intracavernosal pressure relative to that produced by pap/phent/PGE1 and the abscissa indicates the dose of moxisylyte and Example 6 given.

Figure 7 shows the duration of the erectile response *in vivo* in the anesthetized rabbit upon intracavernosal administration of moxisylyte (1 mg) and Example 6 (1 mg). The ordinate indicates the dose of moxisylyte and Example 6 the abscissa is the duration in minutes.

The term "lower alkyl" as used herein refers to branched or straight chain alkyl groups comprising one to ten carbon atoms. including methyl. ethyl. propyl, isopropyl. n-butyl. t-butyl. neopentyl and the like.

The term "alkoxy" as used herein refers to $R_{50}O$- wherein R_{50} is lower alkyl as defined above. Representative examples of alkoxy groups include methoxy. ethoxy.

t-butoxy and the like.

The term "alkoxyalkyl" as used herein refers to an alkoxy group as previously defined appended to an alkyl group as previously defined. Examples of alkoxyalkyl include, but are not limited to, methoxymethyl, methoxyethyl, isopropoxymethyl and the like.

The term "hydroxy" as used herein refers to -OH.

The term "hydroxyalkyl" as used herein refers to a hydroxy group as previously defined appended to a alkyl group as previously defined.

The term "alkenyl" as used herein refers to a branched or straight chain C_2-C_{10} hydrocarbon which also comprises one or more carbon-carbon double bonds.

The term "amino" as used herein refers to $-NH_2$.

The term "carboxy" as used herein refers to -C(O)O-.

The term "nitrate" as used herein refers to $-O-NO_2$.

The term "amido" as used herein refers to -C(O)NH-.

The term "alkylamino" as used herein refers to $R_{11}NH$- wherein R_{11} is a lower alkyl group, for example, methylamino, ethylamino, butylamino, and the like.

The term "alkylamido" as used herein refers to $-C(O)NR_{11}$- wherein R_{11} is defined as above.

The term "dialkylamino" as used herein refers to $R_{12}R_{13}N$- wherein R_{12} and R_{13} are independently selected from lower alkyl, for example dimethylamino, diethylamino, methyl propylamino and the like.

The term "nitro" as used herein refers to the group $-NO_2$ and "nitrosated" refers to

compounds that have been substituted therewith.

The term "nitroso" as used herein refers to the group -NO and "nitrosylated" refers to compounds that have been substituted therewith.

The term "aryl" as used herein refers to a mono- or bicyclic carbocyclic ring system having one or two aromatic rings including, but not limited to, phenyl, naphthyl, tetrahydronaphthyl, indanyl, indenyl, and the like. Aryl groups (including bicyclic aryl groups) can be unsubstituted or substituted with one, two or three substituents independently selected from loweralkyl, haloalkyl, alkoxy, amino, alkylamino, dialkylamino, hydroxy, halo, and nitro. In addition, substituted aryl groups include tetrafluorophenyl and pentafluorophenyl.

The term "arylalkyl" as used herein refers to a lower alkyl radical to which is appended an aryl group. Representative arylalkyl groups include benzyl, phenylethyl, hydroxybenzyl, fluorobenzyl, fluorophenylethyl and the like.

The term "cycloalkyl" as used herein refers to an alicyclic group comprising from 3 to 7 carbon atoms including, but not limited to, cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl and the like.

The term " halogen" or "halo" as used herein refers to I, Br, Cl, or F. The term "haloalkyl" as used herein refers to a lower alkyl radical, as defined above, bearing at least one halogen substituent, for example, chloromethyl, fluoroethyl or trifluoromethyl and the like.

The term "heteroaryl" as used herein refers to a mono- or bi- cyclic ring system containing one or two aromatic rings and containing at least one nitrogen, oxygen, or sulfur atom in an aromatic ring. Heteroaryl groups (including bicyclic heteroaryl groups) can be unsubstituted or substituted with one, two or three substituents independently selected from lower alkyl, haloalkyl, alkoxy, amino, alkylamino, dialkylamino, hydroxy, halo and nitro. Examples of heteroaryl groups include but are not limited to pyridine, pyrazine, pyrimidine, pyridazine, pyrazole, triazole, thiazole, isothiazole, benzothiazole, benzoxazole, thiadiazole, oxazole, pyrrole, imidazole and isoxazole.

The term "heterocyclic ring" refers to any 3-, 4-, 5-, 6-, or 7-membered nonaromatic ring containing at least one nitrogen atom, oxygen atom, or sulfur atom.

The term "arylheterocyclic ring" as used herein refers to a bi- or tricyclic ring comprised of an aryl ring as previously defined appended via two adjacent carbons of the aryl group to a heterocyclic ring as previously defined.

The term "heterocyclic compounds" herein refers to mono and polycyclic compounds containing at least one heteroaryl or heterocyclic ring.

Compounds of the invention which have one or more asymmetric carbon atoms may exist as the optically pure enantiomers, pure diastereomers, mixtures of enantiomers, mixtures of diastereomers, racemic mixtures of enantiomers, diastereomeric racemates or mixtures of diastereomeric racemates. It is to be understood that the present invention anticipates and includes within its scope all such isomers and mixtures thereof.

The α–adrenergic receptor antagonists that are nitrosated or nitrosylated in accordance with the invention and/or are included in the compositions of the invention can be any of those known to the art, including those exemplified below. Structurally, the α– antagonists can generally be categorized as haloalkylamines, imidazolines, quinozolines, indole derivatives, phenoxypropanolamines, alcohols, alkaloids, amines, piperizines and piperidines.

The first group of α–antagonists are the haloalkylamines that block a_1- and a_2-adrenergic receptors irreversibly. Included in this group are, for example, phenoxybenzamine and dibenamine. Phenoxybenzamine is used in the treatment of pheochromocytomas, tumors of the adrenal medulla and sympathetic neurons that secrete catecholamines into the circulation. It controls episodes of severe hypertension and minimizes other adverse effects of catecholamines such as contraction of plasma volume and injury of the myocardium.

Another group of such α–antagonists are the imidazolines. These include phentolamine and tolazoline. Phentolamine has similar affinity for a_1 and a_2 receptors.

Phentolamine is used in short-term control of hypertension in patients with pheochromocytoma and direct, intracavernous injection of phentolamine (usually in combination with papaverine) has been proposed as a treatment for male sexual dysfunction. Tolazoline is used in the treatment of persistent pulmonary hypertension in neonates. Others include idazoxan, deriglidole, RX 821002, BRL 44408 and BRL 44409 (see *Eur. J. Pharm., 168*:381, 1989)

Another group of α–antagonist compounds that are contemplated are the quinazolines. These include, for example, prazosine, a very potent and selective a_1-adrenergic antagonist, terazosin, doxazosin, alfuzosin, bunazosin, ketanserin, trimazosin and abanoquil. This group of compounds is principally used in the treatment of primary systemic hypertension and also in the treatment of congestive heart failure.

Another class of such α–adrenergic blocking agents are indole derivatives. These include, for example, carvedilol and BAM 1303.

Another class of such α–adrenergic blocking agents are alcohols. These include, for example, labetelol and ifenprodil.

Another class of such α–adrenergic blocking agents are alkaloids. These include, for example, "ergotoxine," which is a mixture of three alkaloids, *i.e.*, ergocornine, ergocristine and ergocryptine. Both natural and dihydrogenated peptide alkaloids produce α–adrenergic blockade. The principal uses are to stimulate contraction of the uterus post- partum and to relieve the pain of migraine headaches. Another indole alkaloid is yohimbine. This compound is a competitive antagonist that is selective for a_2-adrenergic receptors. In humans, it has been observed to increase blood pressure and heart rate and has been used in the treatment of male sexual dysfunction. Other alkaloid α–blockers include rauwolscine, corynathine, raubascine, tetrahydroalstonine, apoyohimbine, akuammigine, ß-yohimbine, yohimbol, pseudoyohimbine and epi-3α–yohimbine.

Another class of such α–adrenergic blocking agents are amines. These include, for example, tamsulosin, benoxathian, atipamezole, BE 2254, WB 4101 and HU-723.

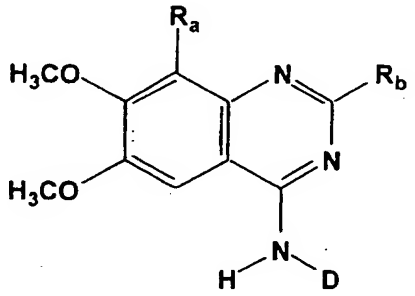
Another class of such α–adrenergic blocking agents are piperizines. These

include. for example. naftopil and saterinone.

Another class of such α–adrenergic blocking agents are piperidines. These include. for example. haloperidol.

Each of the above contemplated α–antagonists is described more fully in the literature, such as in Goodman and Gilman. The Pharmacological Basis of Therapeutics (8th Edition). McGraw-Hill, 1993, Pgs. 638-381.

One embodiment of this aspect includes substituted compounds of the formula:

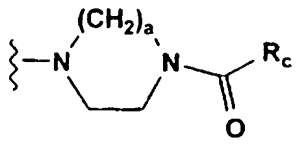


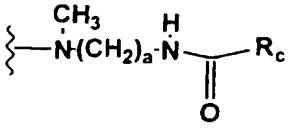
I.

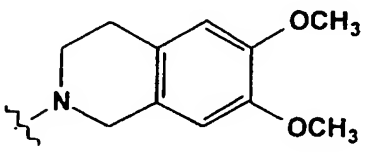
wherein.

R_a is selected from hydrogen or alkoxy;

R_b is selected from

(i) 

(ii) 

(iii) 

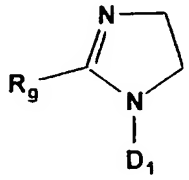
wherein

a is an integer of 2 or 3;

R_c is selected from heteroaryl, heterocyclic ring, lower alkyl, hydroxyalkyl, and arylheterocyclic ring;

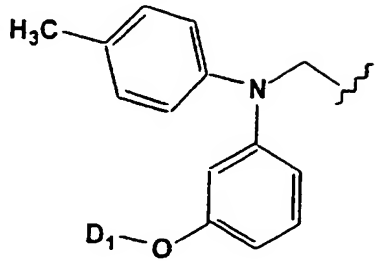
D is selected from (i) -NO; (ii) $-NO_2$; (iii) $-C(R_d)-O-C(O)-Y-Z-[C(R_e)(R_f)]_p-T-Q$ in which R_d is hydrogen, lower alkyl, cycloalkyl, aryl, alkylaryl, aryl or heteroaryl, Y is oxygen, sulfur, or NR_i in which R_i is hydrogen, lower alkyl, R_e and R_f are independently selected from hydrogen, lower alkyl, cycloalkyl, aryl, heteroaryl, arylalkyl, amino, alkylamino, amido, alkylamido, dialkylamino, carboxy, or taken together are carbonyl, cycloalkyl or bridged cycloalkyl, p is an integer from 1 to 6, T is a covalent bond, oxygen, sulfur or nitrogen, Z is selected from a covalent bond, alkyl, cycloalkyl, aryl, heteroaryl, arylalkyl or arylheterocyclic ring, and Q is selected from -NO or $-NO_2$; (iv) $-C(O)-T^1-Z-[C(R_e)(R_f)]_p-T^2-Q$ wherein T^1 and T^2 are independently selected from T and R_e, R_f, p, Q, Z, and T are as defined above; (v) $-C(O)-T[C(R_y)(R_z)]_p$ wherein R_y and R_z are independently selected from $-T^1-[C(R_e)(R_f)]_p-G-[C(R_e)(R_f)]_p-T^2-Q$ wherein G is (*i*) a covalent bond; (*ii*) -T-C(O)-; (*iii*) -C(O)-T, or (*iv*) Y, and wherein R_d, R_e, R_f, p, Q, T, and Y are as defined above;

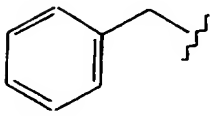
Another embodiment of this aspect is substituted compounds of the formula:

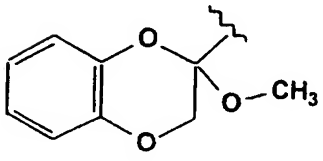


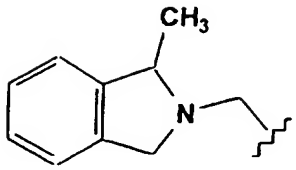
II.

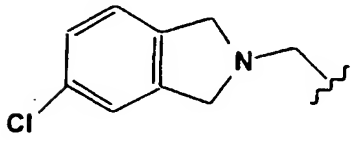
wherein. R_g is selected from:

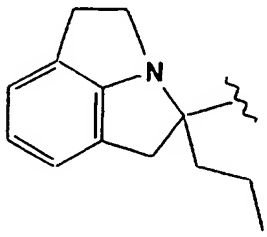
(i) 

(ii) 

(iii) 

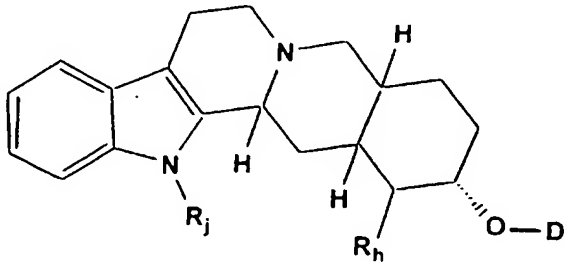
(iv) 

(v) 

(vi) 

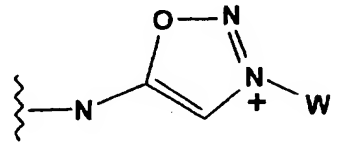
wherein D_1 is selected from hydrogen or D wherein D is as defined above and with the proviso that D_1 must be selected from D if there is no other D in the molecule.

Another embodiment of this aspect includes substituted compounds of the formula:



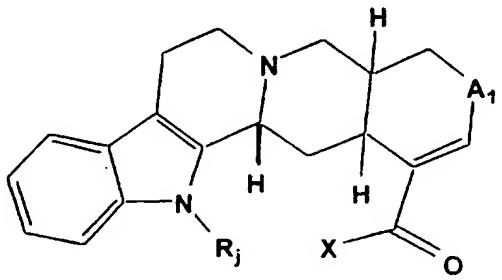
III.

wherein R_h is selected from hydrogen, -C(O)-OR_d or -C(O)-X wherein X is (1) -Y-[$C(R_e)(R_f)$]$_p$-G_i-[$C(R_e)(R_f)$]$_p$-T-Q; wherein G_i is (i) a covalent bond; (ii) -T-C(O)-; (iii) -C(O)-T; (iv) -C(Y-C(O)-R_m)- wherein R_m is heteroaryl or heterocyclic ring; and in which Y , R_d, R_e, R_f, p, Q and T are as defined above; or (2)



in which W is a heterocyclic ring or $NR_iR'_i$ wherein R_i and R'_i are independently selected from lower alkyl, aryl or alkenyl; and wherein R_j is selected from -D, hydrogen, or -(O)CR_d wherein D and R_d are as defined above.

Another embodiment of this aspect includes substituted compounds of the formula:

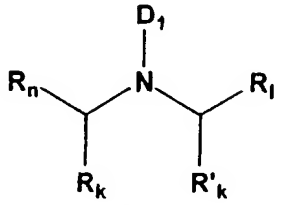


IV.

wherein,

A_1 is oxygen or methylene and X and R_j are as defined above.

Another embodiment of this aspect includes substituted compounds of the formula:

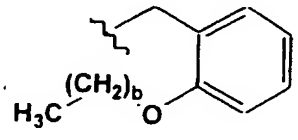


V.

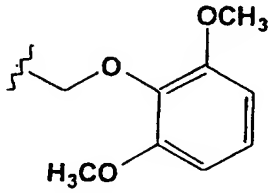
wherein,

R_k and R'_k are independently selected from hydrogen or lower alkyl; and wherein R_l is selected from:

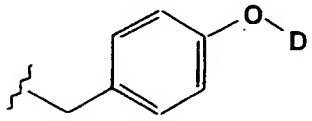
(i)



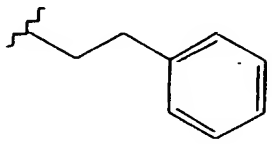
(iii)



(ii)

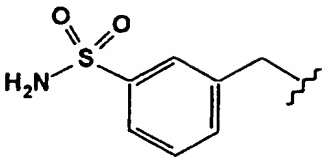


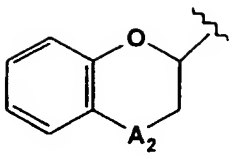
(iv)

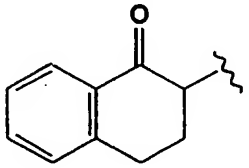


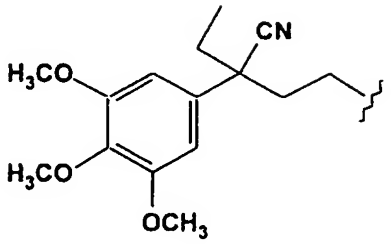
wherein b is an integer of 0 or 1: D and D_1 are as defined above; and

R_n is selected from:

(i) 

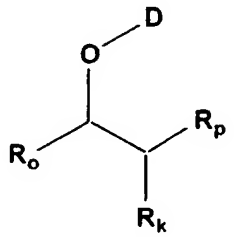
(iii) 

(ii) 

(iv) 

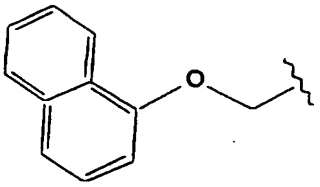
wherein A_2 is oxygen or sulfur.

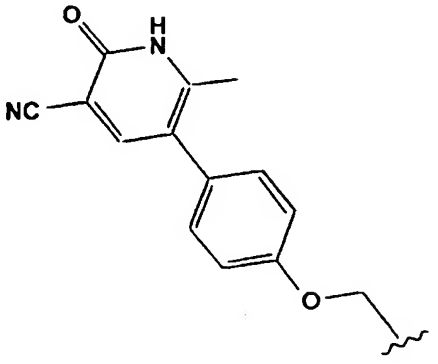
Another embodiment of this aspect includes substituted compounds of the formula:

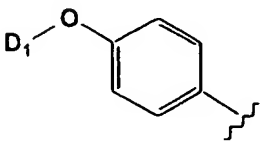


VI.

wherein R_o is selected from:

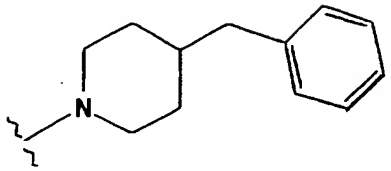
(i) 

(iii) 

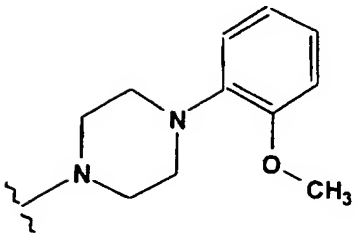
(ii) 

and R_p is selected from:

(i)

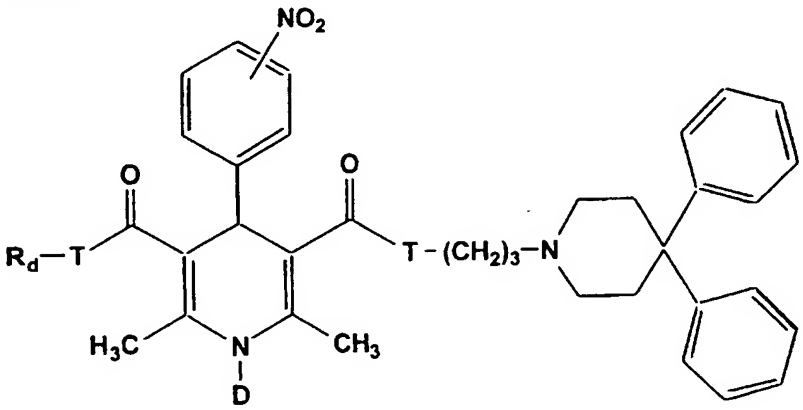


(ii)



aand R_L, D. and D_1 are as defined above.

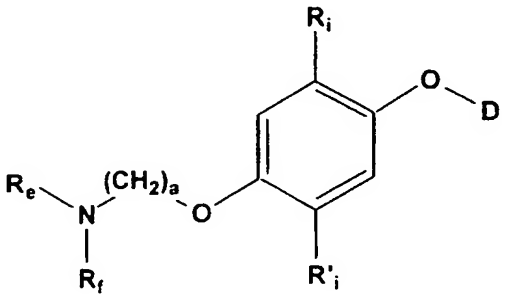
Another embodiment of this aspect includes substituted compounds of the formula:



VII.

wherein R_d, T and D are defined as above.

Another embodiment of this aspect includes substituted compounds of the formula:



VIII.

wherein a, R_i, R'_i, R_e, R_f, and D are defined as above.

The present invention also relates to processes for preparing the compounds of formula (I), (II), (III), (IV), (V), (VI), (VII), or (VIII) and to the intermediates useful in such processes.

Some of the nitrosated and nitrosylated α–antagonists of the present invention

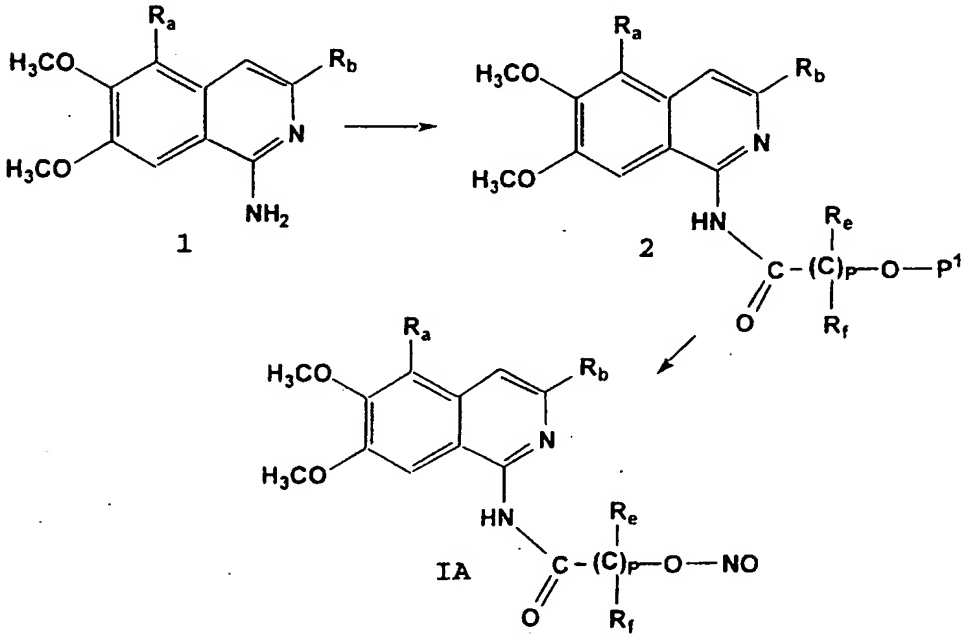
may be synthesized as shown in reaction Schemes I through XXI presented below, in which R_a, R_b, R_c, R_d, R_e, R_f, R_g, R_h, R_i, R'_i, R_j, R_k, R_l, R_m, R_n, R_o, R_p, A_1, A_2, a, n, W and X are as defined above or as depicted in the reaction schemes for formulas **I**, **II**, **III**, **IV**, **V**, **VII**, or **VIII**. P^1 is an oxygen protecting group and P^2 is a sulfur protecting group. The reactions are performed in solvents appropriate to the reagents and materials employed are suitable for the transformations being effected. It is understood by those skilled in the art of organic synthesis that the functionality present in the molecule must be consistent with the chemical transformation proposed. This will, on occasion, necessitate judgment by the routineer as to the order of synthetic steps, protecting groups required, and deprotection conditions. Substituents on the starting materials may be incompatible with some of the reaction conditions required in some of the methods described, but alternative methods and substituents compatible with the reaction conditions will be readily apparent to skilled practitioners in the art. The use of sulfur and oxygen protecting groups is well known in the art for protecting thiol and alcohol groups against undesirable reactions during a synthetic procedure and many such protecting groups are known, *c.f.*, T.H. Greene and P.G.M. Wuts, *Protective Groups in Organic Synthesis*, John Wiley & Sons, New York (1991).

The chemical reactions described above are generally disclosed in terms of their broadest application to the preparation of the compounds of this invention. Occasionally, the reactions may not be applicable as described to each compound included within the disclosed scope. The compounds for which this occurs will be readily recognized by those skilled in the art. In all such cases, either the reactions can be successfully performed by conventional modifications known to those skilled in the art, *e.g.*, by appropriate protection of interfering groups, by changing to alternative conventional reagents, by routine modification of reaction conditions, and the like, or other reactions disclosed herein or otherwise conventional, will be applicable to the preparation of the corresponding compounds of this invention. In all preparative methods, all starting materials are known or readily preparable from known starting materials.

Nitroso compounds of formula (**I**) wherein R_a, R_b, R_c, R_f, and p are as defined above and an O-nitrosylated amide is representative of the D group as defined above may be prepared according to Scheme I. The amine group of the quinazoline of the formula **1** is converted to the amide of the formula **2** wherein p, R_c and R_f are as defined above by

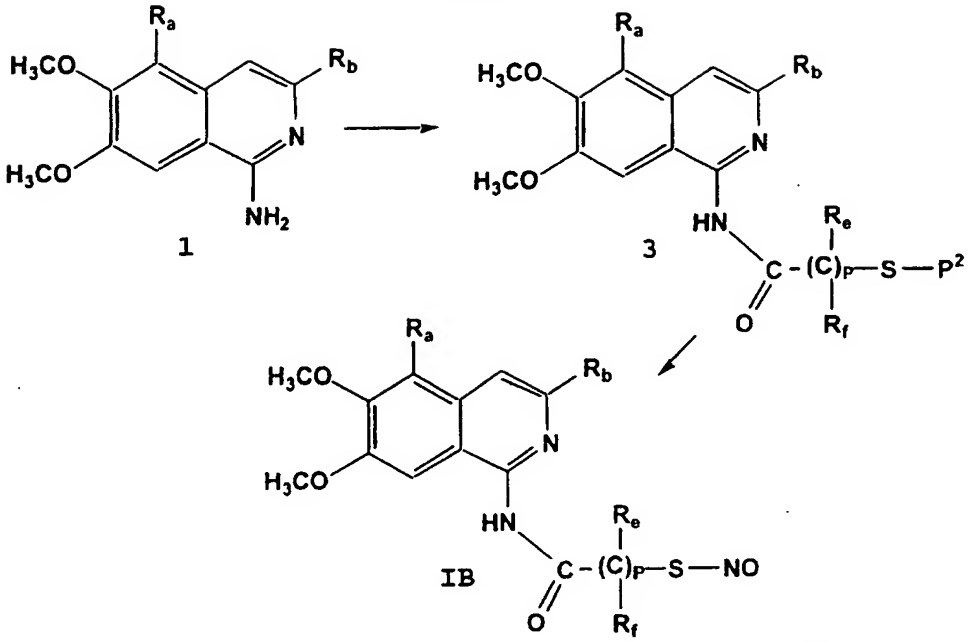
reaction with an appropriate protected alcohol containing activated acylating agent wherein P^1 is as defined above. Preferred methods for the formation of amides are reacting the amine with the preformed acid chloride or symmetrical anhydride of the protected alcohol-containing acid. Preferred protecting groups for the alcohol moiety are silyl ethers such as a trimethylsilyl or a tert-butyldimethylsilyl ether. Deprotection of the hydroxyl moiety (fluoride ion is the preferred method for removing silyl ether protecting groups) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite. thionyl dinitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as dichloromethane, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **IA**.

Scheme I



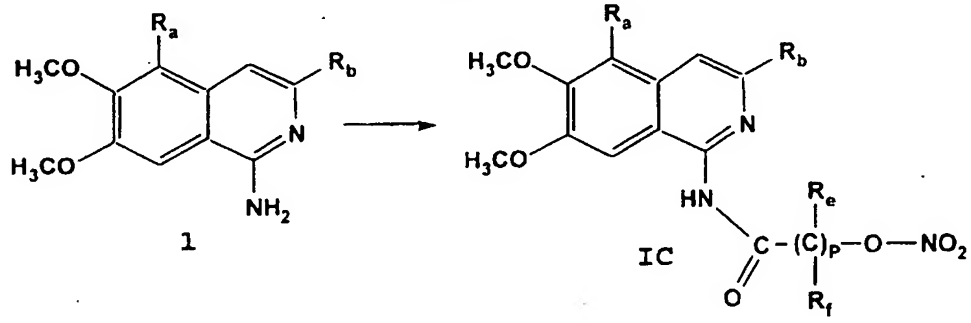
Nitroso compounds of formula (I) wherein R_a, R_b, R_c, R_f, and p are defined as above and an S-nitrosylated amide is representative of the D group as defined above may be prepared according to Scheme II. The amine group of the quinazoline of the formula **1** is converted to the amide of the formula **3** wherein p, R_e and R_f are defined as above by reaction with an appropriate protected thiol-containing activated acylating agent wherein P^2 is as defined above. Preferred methods for the formation of amides are reacting the amine with the preformed acid chloride or symmetrical anhydride of the protected thiol containing acid. Preferred protecting groups for the thiol moiety are as a thioester such as a thioacetate or thiobenzoate, as a disulfide, as a thiocarbamate such as N-methoxymethyl thiocarbamate, or as a thioether such as a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether. Deprotection of the thiol moiety (zinc in dilute aqueous acid, triphenylphosphine in water and sodium borohydride are preferred methods for reducing disulfide groups while aqueous base is typically utilized to hydrolyze thioesters and N-methoxymethyl thiocarbamates and mercuric trifluoroacetate, silver nitrate, or strong acids such as trifluoroacetic or hydrochloric acid and heat are used to remove a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether group) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, a lower alkyl nitrite such as tert-butyl nitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as methyene chloride, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **IB**. Alternatively, treatment of compound **3** with a stoichiometric quantity of sodium nitrite in aqueous acid affords the compound of the formula **IB**.

Scheme II



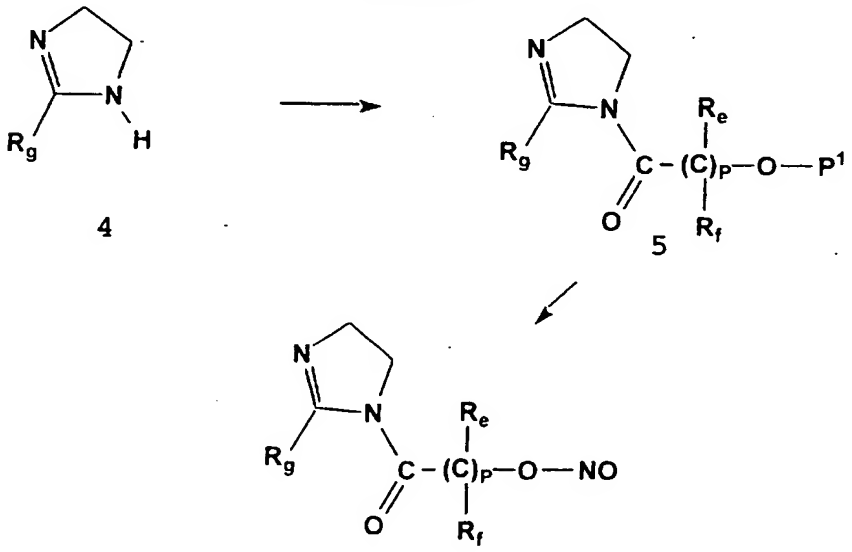
Nitro compounds of formula (I) wherein R_a, R_b, R_e, R_f, and p are defined as above and an O-nitrosated amide is representative of the D group as defined above may be prepared according to Scheme III. The amine group of the quinazoline of the formula 1 is converted to the amide of the formula IC wherein p, R_e and R_f are defined as above by reaction with an appropriate nitrate containing activated acylating agent. Preferred methods for the formation of amides are reacting the amine with the preformed acid chloride or symmetrical anhydride of the nitrate containing acid to afford the compound of the formula IC.

Scheme III



Nitroso compounds of formula (II) wherein R_e, R_f, R_g, and p are defined as above and an O-nitrosylated acyl imidazoline is representative of the D group as defined above may be prepared according to Scheme IV. The imidazoline group of the formula 4 is converted to the acyl imidazoline of the formula 5 wherein p, R_e and R_f are defined as above by reaction with an appropriate protected alcohol containing activated acylating agent wherein P^1 is as defined above. Preferred methods for the formation of acyl imidazolines are reacting the imidazoline with the preformed acid chloride or symmetrical anhydride of the protected alcohol containing acid. Preferred protecting groups for the alcohol moiety are silyl ethers such as a trimethylsilyl or a tert-butyldimethylsilyl ether. Deprotection of the hydroxyl moiety (fluoride ion is the preferred method for removing silyl ether protecting groups) followed by reaction with a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as dichloromethane, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **IIA**.

Scheme IV

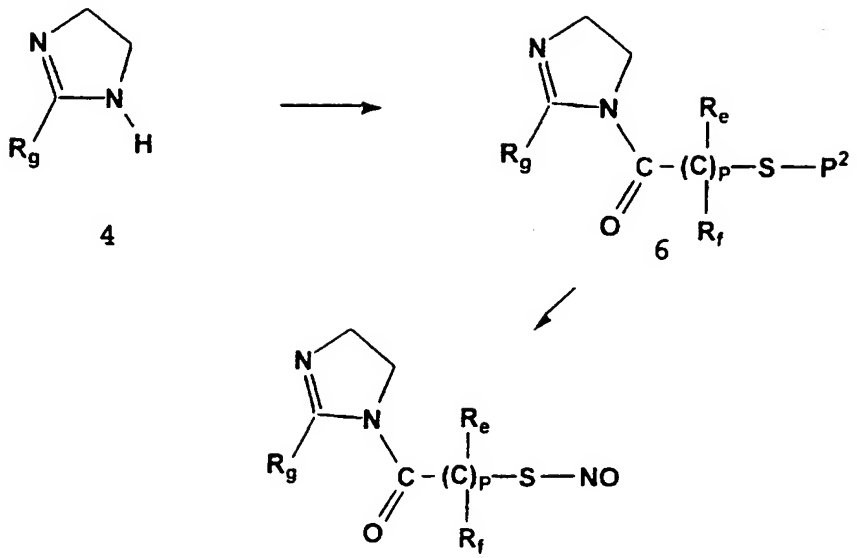


IIA

Nitroso compounds of formula (II) wherein R_e, R_f, R_g, and p are defined as above

and an S-nitrosylated acyl imidazoline is representative of the D group as defined above may be prepared according to Scheme V. The imidazoline group of the formula **4** is converted to the acyl imidazoline of the formula **6** wherein p, R_e and R_f are defined as above by reaction with an appropriate protected thiol containing activated acylating agent wherein P^2 is as defined above. Preferred methods for the formation of acyl imidazolines are reacting the imidazoline with the preformed acid chloride or symmetrical anhydride of the protected thiol containing acid. Preferred protecting groups for the thiol moiety are as a thioester such as a thioacetate or thiobenzoate, as a disulfide, as a thiocarbamate such as N-methoxymethyl thiocarbamate, or as a thioether such as a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether. Deprotection of the thiol moiety (zinc in dilute aqueous acid, triphenylphosphine in water and sodium borohydride are preferred methods for reducing disulfide groups while aqueous base is typically utilized to hydrolyze thioesters and N- methoxymethyl thiocarbamates and mercuric trifluoroacetate, silver nitrate, or strong acids such as trifluoroacetic or hydrochloric acid and heat are used to remove a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether group) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, a lower alkyl nitrite such as tert-butyl nitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as methyene chloride, THF, DMF or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **IIB**. Alternatively, treatment of compound **6** with a stoichiometric quantity of sodium nitrite in aqueous acid affords the compound of the formula **IIB**.

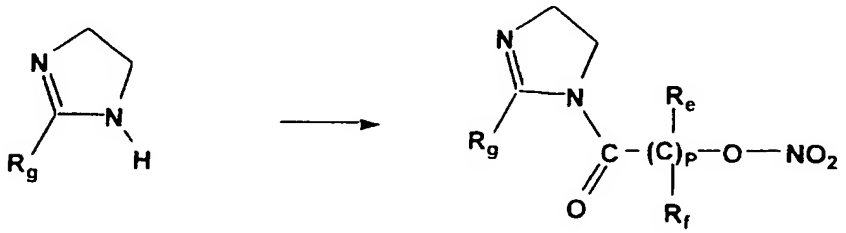
Scheme V



4 6 IIB

Nitro compounds of formula (II) wherein R_e, R_f, R_g, and p are defined as above and an O-nitrosated acyl imidazoline is representative of the D group as defined above may be prepared according to Scheme VI. The imidazoline group of the formula 4 is converted to the acyl imidazoline of the formula IIC wherein p, R_e and R_f are defined as above by reaction with an appropriate nitrate containing activated acylating agent. Preferred methods for the formation of acyl imidazolines are reacting the amine with the preformed acid chloride or symmetrical anhydride of the nitrate containing acid to afford the compound of the formula IC.

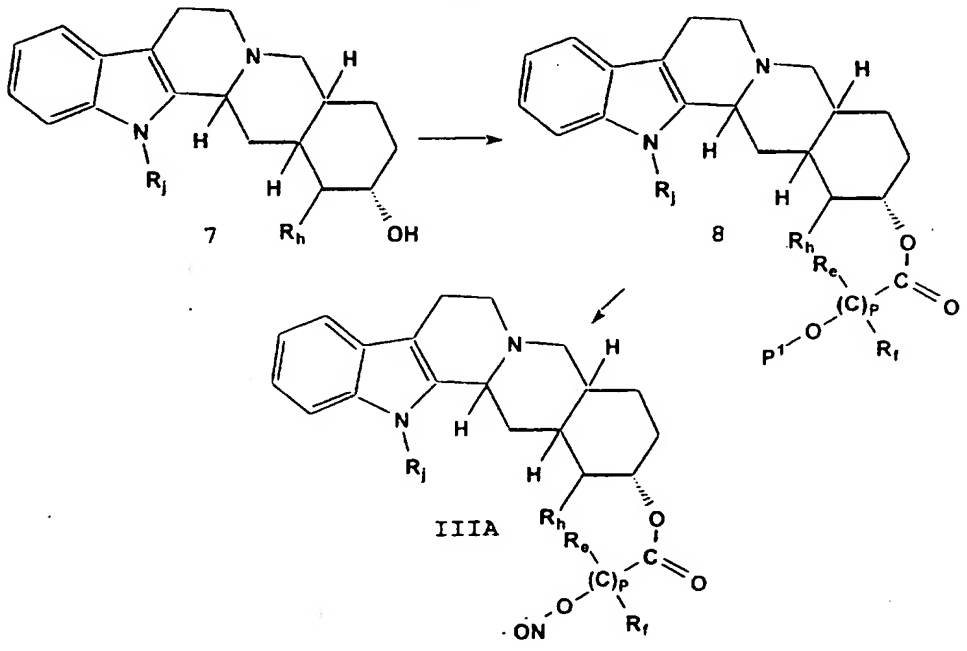
Scheme VI



4 IIC

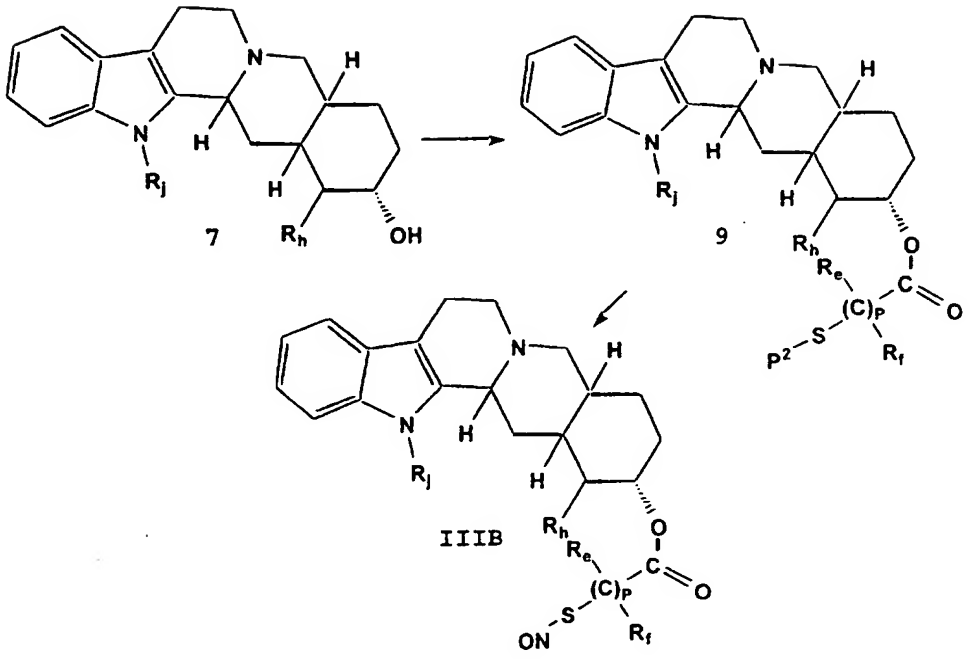
Nitroso compounds of formula (III) wherein R_e, R_f, R_h, R_j, and p are defined as above and an O-nitrosylated ester is representative of the D group as defined above may be prepared according to Scheme VII. The alcohol group of formula 7 is converted to the ester of formula 8 wherein p, R_e and R_f are defined as above by reaction with an appropriate protected alcohol containing activated acylating agent wherein P^1 is as defined above. Preferred methods for the formation of esters are reacting the alcohol with the preformed acid chloride or symmetrical anhydride of the protected alcohol containing acid. Preferred protecting groups for the alcohol moiety are silyl ethers such as a trimethylsilyl or a tert-butyldimethylsilyl ether. Deprotection of the hydroxyl moiety (fluoride ion is the preferred method for removing silyl ether protecting groups) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as dichloromethane, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula IIIA.

Scheme VII



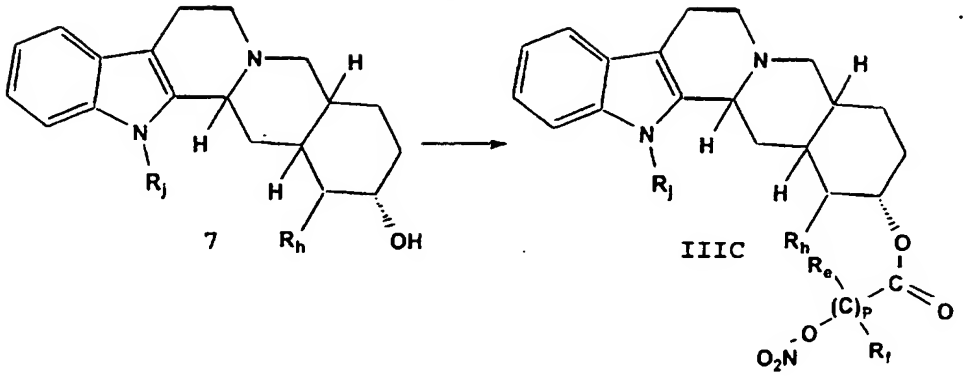
Nitroso compounds of formula (**III**) wherein R_e, R_f, R_h, R_j, and p are defined as above and an S-nitrosylated ester is representative of the D group as defined above may be prepared according to Scheme VIII. The alcohol group of the formula 7 is converted to the ester of the formula 9 wherein p, R_e and R_f are defined as above by reaction with an appropriate protected thiol containing activated acylating agent wherein P^2 is as defined above. Preferred methods for the formation of esters are reacting the alcohol with the preformed acid chloride or symmetrical anhydride of the protected thiol containing acid. Preferred protecting groups for the thiol moiety are as a thioester such as a thioacetate or thiobenzoate, as a disulfide, as a thiocarbamate such as N-methoxymethyl thiocarbamate, or as a thioether such as a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether. Deprotection of the thiol moiety (zinc in dilute aqueous acid, triphenylphosphine in water and sodium borohydride are preferred methods for reducing disulfide groups while aqueous base is typically utilized to hydrolyze thioesters and N-methoxymethyl thiocarbamates and mercuric trifluoroacetate, silver nitrate, or strong acids such as trifluoroacetic or hydrochloric acid and heat are used to remove a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether group) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, a lower alkyl nitrite such as tert-butyl nitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as methyene chloride, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **IIIB**. Alternatively, treatment of compound 9 with a stoichiometric quantity of sodium nitrite in aqueous acid affords the compound of the formula **IIIB**.

Scheme VIII



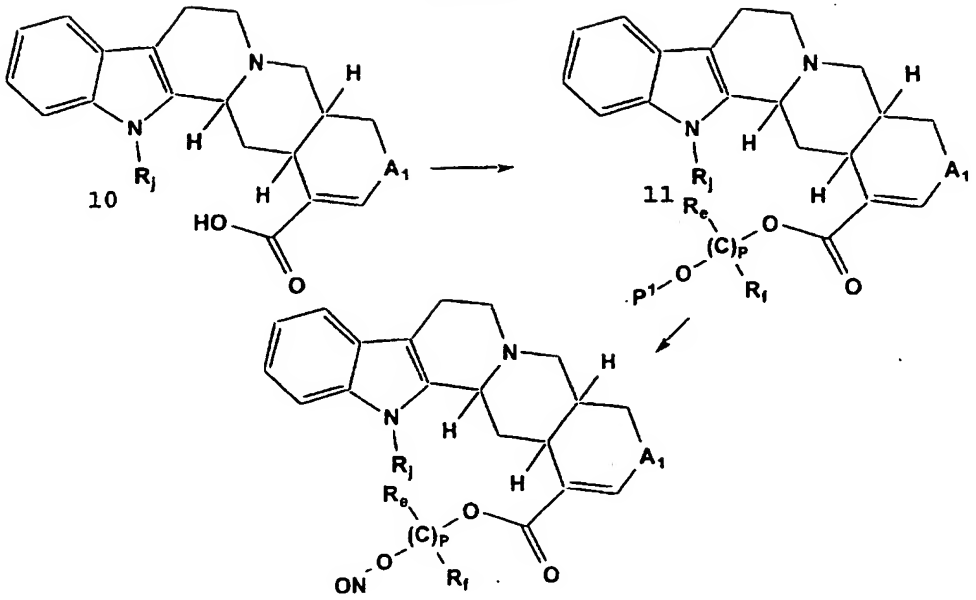
Nitro compounds of formula (**III**) wherein R_e, R_f, R_h, R_j, and p are defined as above and an O-nitrosated ester is representative of the D group as defined above may be prepared according to Scheme IX. The alcohol group of the formula 7 is converted to the ester of the formula **IIIC** wherein p, R_e and R_f are defined as above by reaction with an appropriate nitrate containing activated acylating agent. Preferred methods for the formation of esters are reacting the alcohol with the preformed acid chloride or symmetrical anhydride of the nitrate containing acid to afford a compound of the formula **IIIC**.

Scheme IX



Nitroso compounds of formula (IV) wherein A_1, R_e, R_f, R_h, R_j, and p are defined as above and an O-nitrosylated ester is representative of the X group as defined above may be prepared according to Scheme X. An acid of the formula **10** is converted into the ester of the formula **11** wherein p, R_e, and R_f are defined as above by reaction with an appropriate monoprotected diol. Preferred methods for the preparation of esters are initially forming the mixed anhydride via reaction of **10** with a chloroformate such as isobutylchloroformate in the presence of a non nucleophilic base such as triethylamine in an anhydrous inert solvent such as dichloromethane, diethylether, or THF. The mixed anhydride is then reacted with the monoprotected alcohol preferably in the presence of a condensation catalyst such as 4-dimethylaminopyridine. Alternatively, the acid **10** may be first converted to the acid chloride be treatment with oxalyl chloride in the presence of a catalytic amount of DMF. The acid chloride is then reacted with the monoprotected alcohol preferably in the presence of a condensation catalyst such as 4-dimethylamino-pyridine and a tertiary amine base such as triethyl amine to afford the ester **11**. Alternatively, the acid **10** and monoprotected diol may be coupled to afford **11** by treatment with a dehydration agent such as dicyclohexylcarbodiimide. Preferred protecting groups for the alcohol moiety are silyl ethers such as a trimethylsilyl or a tert-butyldimethylsilyl ether. Deprotection of the hydroxyl moiety (fluoride ion is the preferred method for removing silyl ether protecting groups) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as dichloromethane, THF, DMF, or acetonitrile affords the compound of the formula **IVA**.

Scheme X

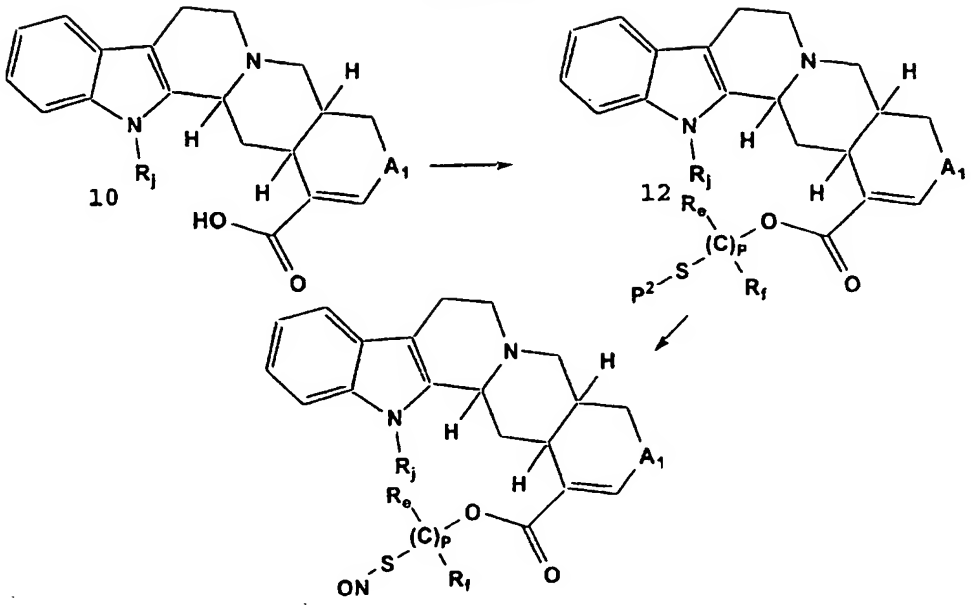


IVA

Nitroso compounds of formula (IV) wherein A_1, R_c, R_f, R_h, R_j, and p are defined as above and an S-nitrosylated ester is representative of the X group as defined above may be prepared according to Scheme XI. An acid of the formula **10** is converted into the ester of the formula **12** wherein p, R_c, and R_f are defined as above and a S-nitrosylated ester is representative of the X group as defined above by reaction with an appropriate protected thiol containing alcohol. Preferred methods for the preparation of esters are initially forming the mixed anhydride via reaction of **10** with a chloroformate such as isobutylchloroformate in the presence of a non nucleophilic base such as triethylamine in an anhydrous inert solvent such as diethylether or THF. The mixed anhydride is then reacted with the thiol containing alcohol preferably in the presence of a condensation catalyst such as 4-dimethylaminopyridine. Alternatively, the acid **10** may be first converted to the acid chloride be treatment with oxalyl chloride in the presence of a catalytic amount of DMF. The acid chloride is then reacted with the monoprotected thiol preferably in the presence of a condensation catalyst such as 4-dimethylaminopyridine and a tertiary amine base such as triethyl amine to afford the ester **12**. Alternatively, the acid and thiol containing alcohol may be coupled to afford **12** by treatment with a

dehydration agent such as dicyclohexylcarbodiimide. Preferred protecting groups for the thiol moiety are as a thioester such as a thioacetate or thiobenzoate, as a disulfide, as a thiocarbamate such as N-methoxymethyl thiocarbamate, or as a thioether such as a paramethoxybenzyl thioether, a tetrahydropyranyl thioether, or a S-triphenylmethyl thioether. Deprotection of the thiol moiety (zinc in dilute aqueous acid, triphenylphosphine in water and sodium borohydride are preferred methods for reducing disulfide groups while aqueous base is typically utilized to hydrolyze thiolesters and N-methoxymethyl thiocarbamates and mercuric trifluoroacetate, silver nitrate, or strong acids such as trifluoroacetic or hydrochloric acid and heat are used to remove a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether group) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, a lower alkyl nitrite such as tert-butyl nitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as methylene chloride, THF, DMF or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **IVB**. Alternatively, treatment of compound **12** with a stoichiometric quantity of sodium nitrite in aqueous acid affords the compound of the formula **IVB**.

Scheme XI

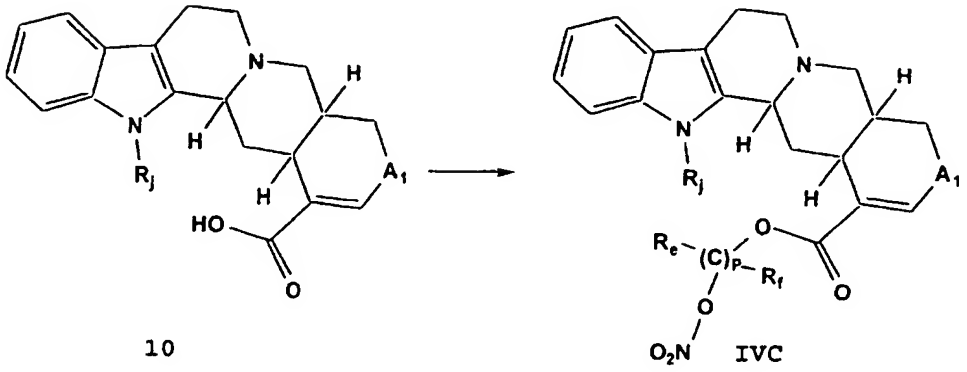


IVB

Nitro compounds of formula (IV) wherein A_1, R_e, R_f, R_h, R_j, and p are defined as above and an O-nitrosated ester is representative of the X group as defined above may be prepared according to Scheme XII. An acid of the formula **10** is converted into the ester of the formula **IVC** wherein p, R_e, and R_f are defined as above by reaction with an appropriate nitrate containing alcohol. Preferred methods for the preparation of esters are initially forming the mixed anhydride via reaction of **10** with a chloroformate such as isobutylchloroformate in the presence of a non nucleophilic base such as triethylamine in an anhydrous inert solvent such as dichloromethane, diethylether, or THF. The mixed anhydride is then reacted with the nitrate containing alcohol preferably in the presence of a condensation catalyst such as 4-dimethylamino-pyridine. Alternatively, the acid **10** may be first converted to the acid chloride be treatment with oxalyl chloride in the presence of a catalytic amount of DMF. The acid chloride is then reacted with the nitrate containing alcohol preferably in the presence of a condensation catalyst such as 4-dimethylaminopyridine and a tertiary amine base such as triethyl amine to afford the a compound of the formula **IVC**. Alternatively, the acid **10** and nitrate containing alcohol may be coupled to afford a compound of the formula **IVC** by treatment with a

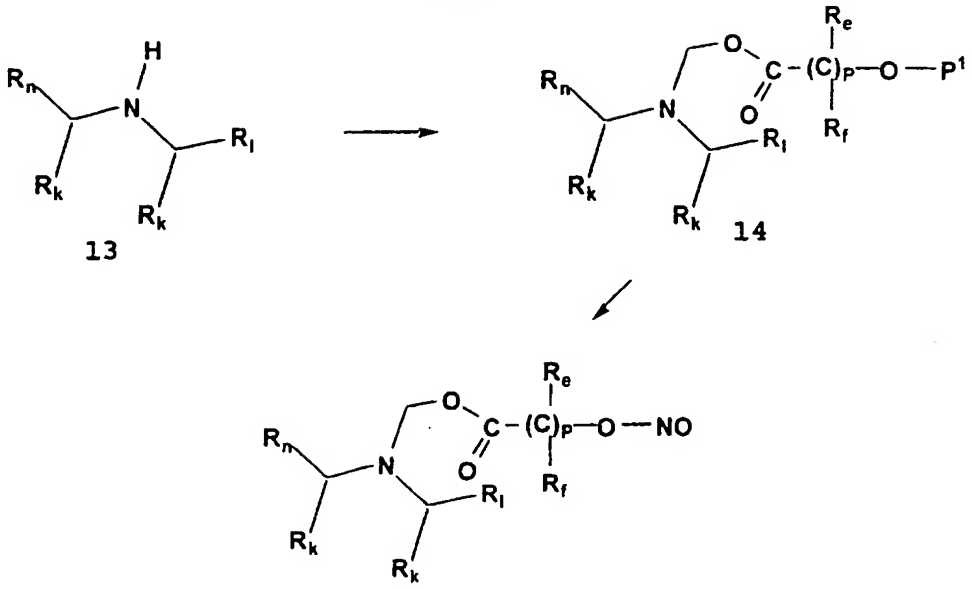
dehydration agent such as dicyclohexylcarbodiimide.

Scheme XII



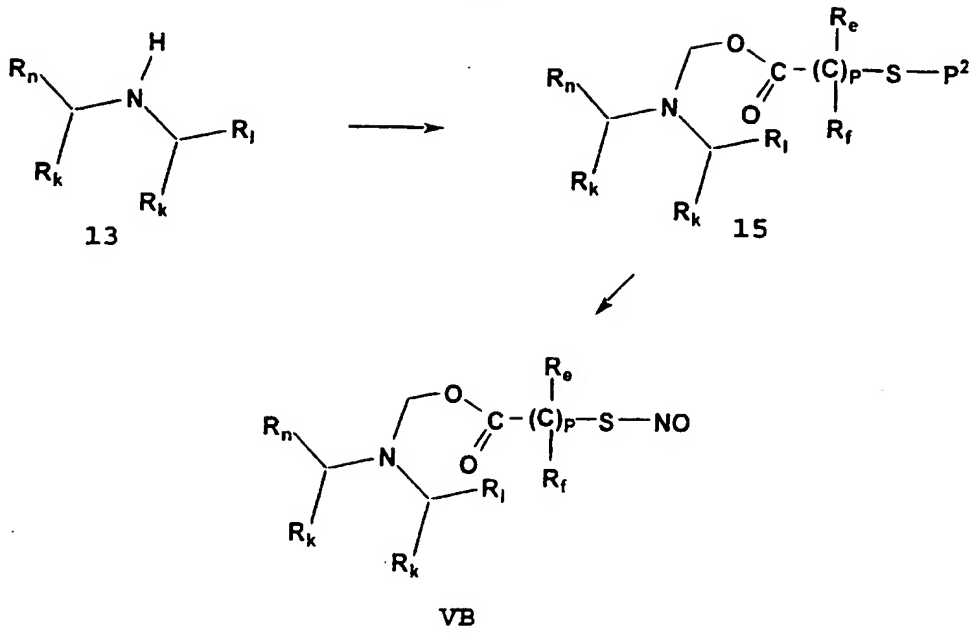
Nitroso compounds of formula (V) wherein R_e, R_f, R_k, R_l, R_n, and p are defined as above and an O-nitrosylated N-acyloxyalkyl amine is representative of the D group as defined above may be prepared according to Scheme XIII. The amine group of the compound of the formula **13** is converted to the N-acyloxyalkyl amine of the formula **14** wherein p, R_e, and R_f are defined as above by reaction with an appropriate protected alcohol containing chloromethyl acyl derivative wherein P^1 is as defined above. Preferred methods for the formation of N-acyloxyalkyl amines are reacting the amine with the preformed chloromethyl acyloxyalkyl derivative of the protected alcohol. Preferred protecting groups for the alcohol moiety are silyl ethers such as a triethylsilyl or a tert- butyldimethylsilyl ether. Deprotection of the hydroxyl moiety (fluoride ion is the preferred method for removing silyl ether protecting groups) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as dichloromethane, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula VA.

Scheme XIII



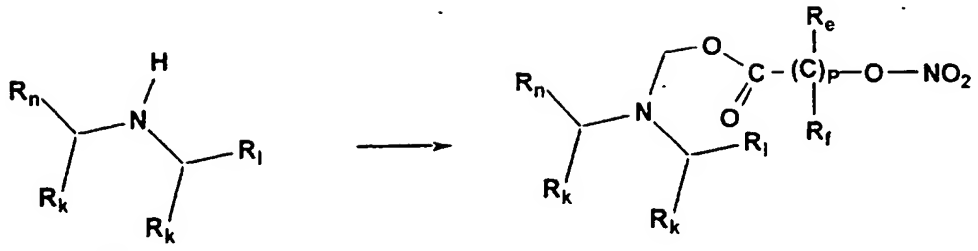
Nitroso compounds of formula (V) wherein R_e, R_f, R_k, R_l, R_n, and p are defined as above and an S-nitrosylated N-acyloxyalkyl amine is representative of the D group as defined above may be prepared according to Scheme XIV. The amine group of the compound of the formula 13 is converted to the N-acyloxyalkyl amine of the formula 15 wherein p, R_e, and R_f are defined as above by reaction with an appropriate protected thiol containing chloromethyl acyl derivative wherein P^2 is as defined above. Preferred protecting groups for the thiol moiety are as a thioester such as a thioacetate or thiobenzoate, as a disulfide, as a thiocarbamate such as N-methoxymethyl thiocarbamate, or as a thioether such as a tetrahydropyranyl thioether. Deprotection of the thiol moiety (triphenylphosphine in water and sodium borohydride are preferred methods for reducing disulfide groups while aqueous base is typically utilized to hydrolyze thioesters and N-methoxymethyl thiocarbamates and mercuric trifluoroacetate or silver nitrate are used to remove a tetrahydropyranyl thioether group) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, a lower alkyl nitrite such as tert-butyl nitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as methyene chloride, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula VB.

Scheme XIV



Nitro compounds of formula (V) wherein R_e, R_f, R_k, R_l, R_n, and p are defined as above and an O-nitrosated N-acyloxyalkyl amine is representative of the D group as defined above may be prepared according to Scheme XV. The amine group of the compound of the formula **13** is converted to the N-acyloxyalkyl amine of the formula **VC** wherein p, R_e, and R_f are defined as above by reaction with an appropriate nitrate containing chloromethyl acyl derivative. Preferred methods for the formation of N-acyloxyalkyl amines are reacting the amine with the preformed chloromethyl acyloxyalkyl derivative of the nitrate containing derivative to afford the compound of the formula **VC**.

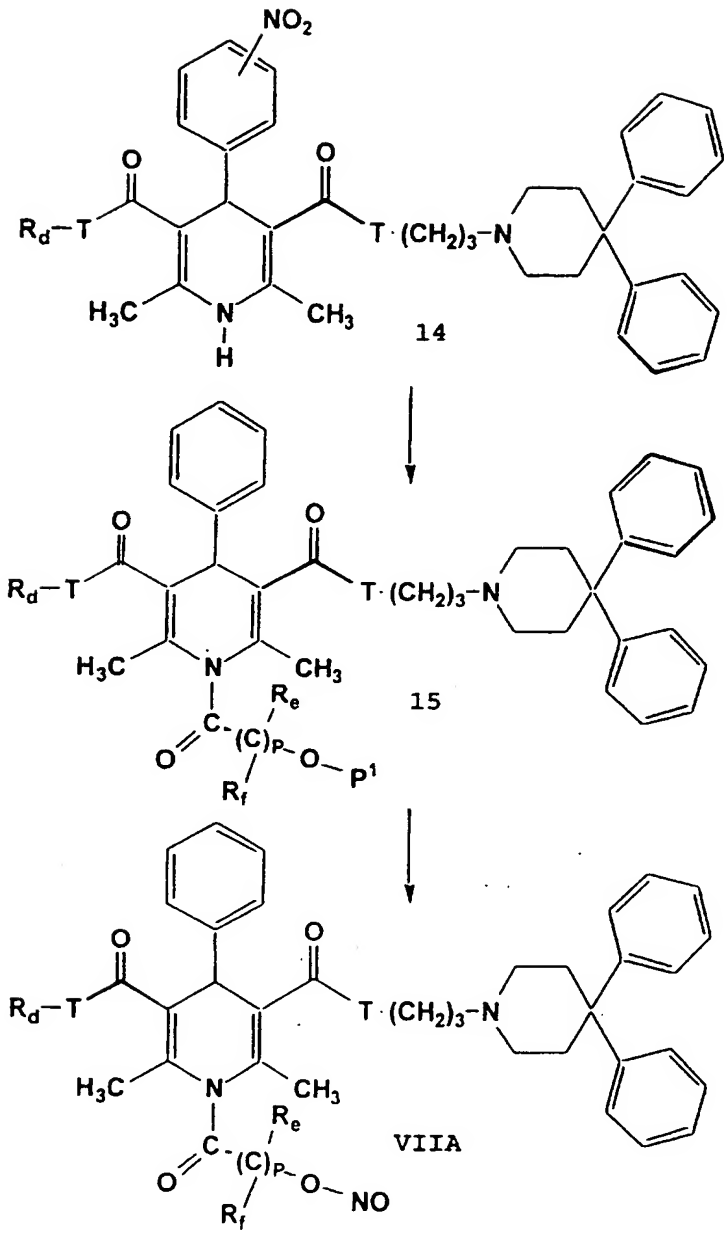
Scheme XV



13 VC

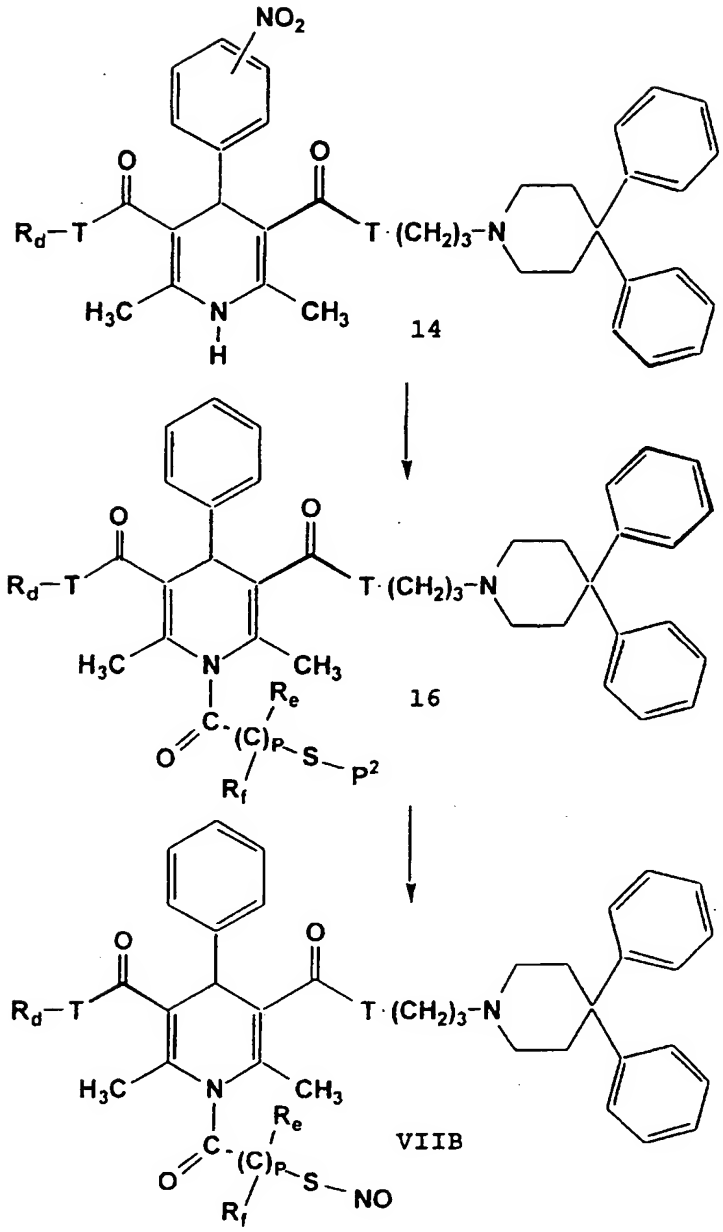
Nitroso compounds of formula (**VII**) wherein R_d, R_e, R_f, T, and p are defined as above and an O-nitrosylated amide is representative of the D group as defined above may be prepared according to Scheme XVI. The amine group of the dihydropyridine of the formula **14** is converted to the amide of the formula **15** wherein p, R_e and R_f are defined as above by reaction with an appropriate protected alcohol containing activated acylating agent wherein P' is as defined above. Preferred methods for the formation of amides are reacting the amine with the preformed acid chloride or symmetrical anhydride of the protected alcohol containing acid. Preferred protecting groups for the alcohol moiety are silyl ethers such as a trimethylsilyl or a tert-butyldimethylsilyl ether. Deprotection of the hydroxyl moiety (fluoride ion is the preferred method for removing silyl ether protecting groups) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as dichloromethane, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **VIIA**.

Scheme XVI



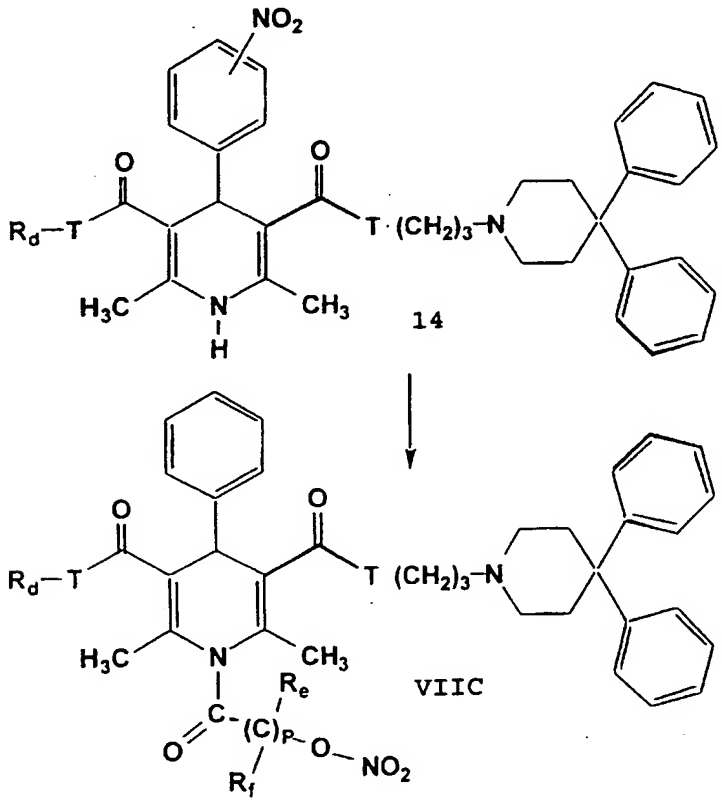
Nitroso compounds of formula (**VII**) wherein R_d, R_e, R_f, T, and p are defined as above and an S-nitrosylated amide is representative of the D group as defined above may be prepared according to Scheme XVII. The amine group of the dihydropyridine of the formula **14** is converted to the amide of the formula **16** wherein p, R_e and R_f are defined as above by reaction with an appropriate protected thiol containing activated acylating agent wherein P^2 is as defined above. Preferred methods for the formation of amides are reacting the amine with the preformed acid chloride or symmetrical anhydride of the protected thiol containing acid. Preferred protecting groups for the thiol moiety are as a thioester such as a thioacetate or thiobenzoate, as a disulfide, as a thiocarbamate such as N-methoxymethyl thiocarbamate, or as a thioether such as a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether. Deprotection of the thiol moiety (zinc in dilute aqueous acid, triphenylphosphine in water and sodium borohydride are preferred methods for reducing disulfide groups while aqueous base is typically utilized to hydrolyze thioesters and N-methoxymethyl thiocarbamates and mercuric trifluoroacetate, silver nitrate, or strong acids such as trifluoroacetic or hydrochloric acid and heat are used to remove a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether group) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, a lower alkyl nitrite such as tert-butyl nitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as methyene chloride, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **VIIB**. Alternatively, treatment of compound **16** with a stoichiometric quantity of sodium nitrite in aqueous acid affords the compound of the formula **VIIB**.

Scheme XVII



Nitro compounds of formula (**VII**) wherein R_d, R_e, R_f, T, and p are defined as above and an O-nitrosated amide is representative of the D group as defined above may be prepared according to Scheme XVIII. The amine group of the dihydropyridine of the formula **14** is converted to the amide of the formula **VIIC** wherein p, R_e and R_f are defined as above by reaction with an appropriate nitrate containing activated acylating agent. Preferred methods for the formation of amides are reacting the amine with the preformed acid chloride or symmetrical anhydride of the nitrate containing acid to afford the compound of the formula **VIIC**.

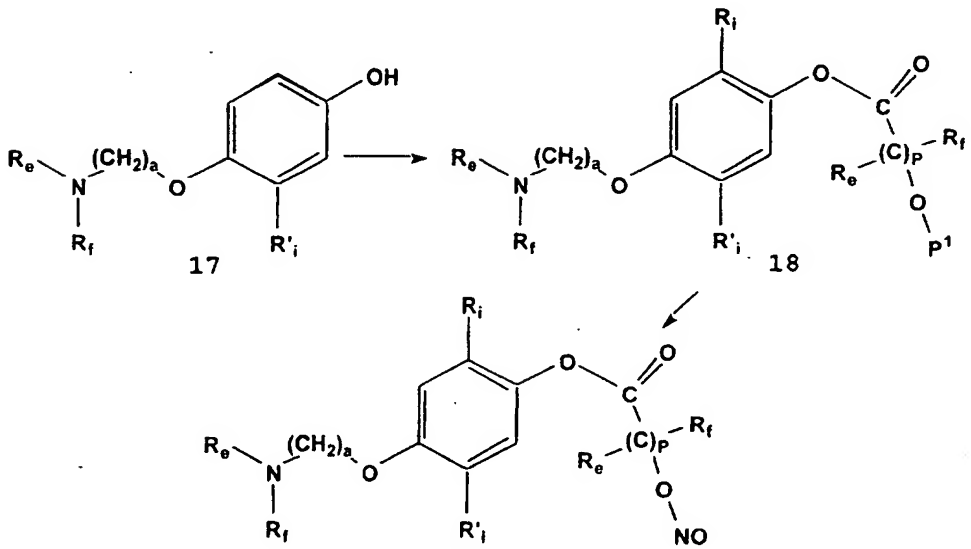
Scheme XVIII



Nitroso compounds of formula (**VIII**) wherein R_e, R_f, R_i, R'_i, a and p are defined as above and an O-nitrosylated ester is representative of the D group as defined above

may be prepared according to Scheme XIX. The hydroxyl group of the phenol of the formula **17** is converted to the ester of the formula **18** wherein a. p. R_e and R_f are defined as above by reaction with an appropriate protected alcohol containing activated acylating agent wherein P^1 is as defined above. Preferred methods for the formation of esters are reacting the hydroxyl with the preformed acid chloride or symmetrical anhydride of the protected alcohol containing acid. Preferred protecting groups for the alcohol moiety are silyl ethers such as a trimethylsilyl or a tert-butyldimethylsilyl ether. Deprotection of the hydroxyl moiety (fluoride ion is the preferred method for removing silyl ether protecting groups) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite. thionyl dinitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as dichloromethane, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **VIIIA**.

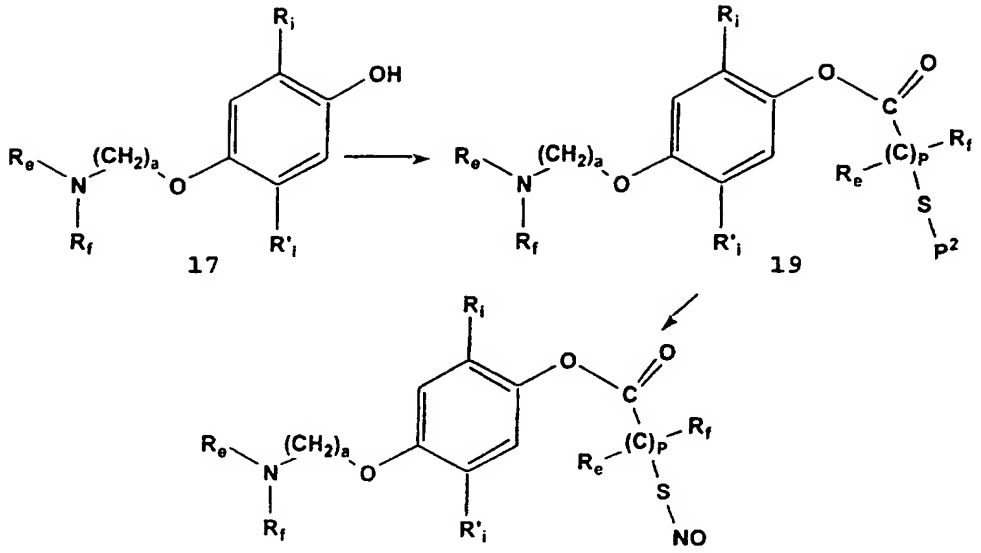
Scheme XIX



Nitroso compounds of formula (**VIII**) wherein R_e, R_f, R_i, R'_i, a. and p are defined as above and an S-nitrosylated ester is representative of the D group as defined

above may be prepared according to Scheme XX. The hydroxyl group of the phenol of the formula **17** is converted to the ester of the formula **19** wherein a, p, R_e and R_f are defined as above by reaction with an appropriate protected thiol containing activated acylating agent wherein P^2 is as defined above. Preferred methods for the formation of esters are reacting the hydroxyl with the preformed acid chloride or symmetrical anhydride of the protected thiol containing acid. Preferred protecting groups for the thiol moiety are as a thioester such as a thioacetate or thiobenzoate, as a disulfide, as a thiocarbamate such as N- methoxymethyl thiocarbamate, or as a thioether such as a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether. Deprotection of the thiol moiety (zinc in dilute aqueous acid, triphenylphosphine in water and sodium borohydride are preferred methods for reducing disulfide groups while aqueous base is typically utilized to hydrolyze thioesters and N-methoxymethyl thiocarbamates and mercuric trifluoroacetate, silver nitrate, or strong acids such as trifluoroacetic or hydrochloric acid and heat are used to remove a paramethoxybenzyl thioether, a tetrahydropyranyl thioether or a S-triphenylmethyl thioether group) followed by reaction a suitable nitrosylating agent such as thionyl chloride nitrite, thionyl dinitrite, a lower alkyl nitrite such as tert-butyl nitrite, or nitrosium tetrafluoroborate in a suitable anhydrous solvent such as methyene chloride, THF, DMF, or acetonitrile with or without an amine base such as pyridine or triethylamine affords the compound of the formula **VIIIB**. Alternatively, treatment of compound **17** with a stoichiometric quantity of sodium nitrite in aqueous acid affords the compound of the formula **VIIIB**.

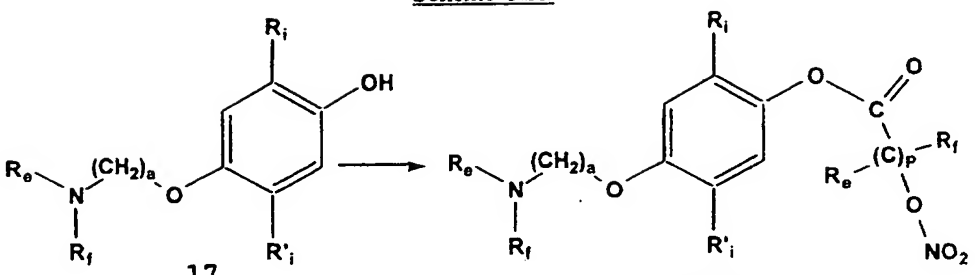
Scheme XX



17 19 VIIIB

Nitro compounds of formula (**VIII**) wherein R_e, R_f, R_i, R'_i, a, and p are defined as above and an O-nitrosated ester is representative of the D group as defined above may be prepared according to Scheme XXI. The hydroxyl group of the phenol of the formula **15** is converted to the ester of the formula **VIIIC** wherein a, p, R_e and R_f are defined as above by reaction with an appropriate nitrate containing activated acylating agent. Preferred methods for the formation of amides are reacting the amine with the preformed acid chloride or symmetrical anhydride of the nitrate containing acid to afford the compound of the formula **VIIIC**.

Scheme XXI



17 VIIIC

As noted above. another aspect the invention provides a composition comprising a therapeutically effective amount of an α–adrenergic receptor antagonist (α–antagonist). which can optionally be substituted with at least one NO or NO_2 moiety. and a compound that donates. transfers or releases nitric oxide as a charged species. *i.e.*. nitrosonium (NO^+) or nitroxyl (NO^-). or as the neutral species. nitric oxide (NO•).

Another embodiment of this aspect is one where the α–blocker is not substituted with at least one NO or NO_2 moiety. Additional α–blockers that are suitable for this embodiment include amines. such as tedisamil. mirtazipine. setiptiline. reboxitine and delequamine: amides. such as indoramin and SB 216469; piperizines. such as SL 89.0591. ARC 239. urapidil. 5-methylurapidil and monatepil. Indoramin is a selective. competitive a_1-antagonist that has been used for the treatment of hypertension. Urapidil is also known to be a selective a_1-adrenergic antagonist that has a hypotensive effect in humans.

The compounds that donate. transfer or release nitric oxide can be any of those known to the art. including those mentioned and/or exemplified below.

Nitrogen monoxide can exist in three forms: NO^- (nitroxyl), NO• (nitric oxide) and NO^+ (nitrosonium). NO• is a highly reactive short-lived species that is potentially toxic to cells. This is critical. because the pharmacological efficacy of NO depends upon the form in which it is delivered. In contrast to NO•. nitrosonium and nitroxyl do not react with O_2 or O_2^- species. and are also resistant to decomposition in the presence of redox metals. Consequently. administration of NO equivalents does not result in the generation of toxic by-products or the elimination of the active NO moiety.

Compounds contemplated for use in the invention are nitric oxide and compounds that release nitric oxide or otherwise directly or indirectly deliver or transfer nitric oxide to a site of its activity, such as on a cell membrane, *in vivo*. As used here, the term "nitric oxide" encompasses uncharged nitric oxide (NO•) and charged nitric oxide species, particularly including nitrosonium ion (NO^+) and nitroxyl ion (NO^-). The reactive form of nitric oxide can be provided by gaseous nitric oxide. The nitric oxide releasing, delivering or transferring compounds, having the structure F-NO wherein F is a nitric oxide releasing, delivering or transferring moiety, include any and all such compounds which provide nitric oxide to its intended site of action in a form active for their intended purpose. As used here, the term "NO adducts" encompasses any of such nitric oxide releasing, delivering or transferring compounds, including, for example, S-nitrosothiols, S-nitrothiols, O-nitrosoalcohols, O-nitroalcohols, sydnonimines, 2-hydroxy-2-nitrosohydrazines (NONOates), (E)-alkyl-2-[(E)-hydroxyimino]-5-nitro-3-hexene amines or amides, nitrosoamines, as well a subtstates for the endogenous enzymes which synthesize nitric oxide. It is contemplated that any or all of these "NO adducts" can be mono- or poly-nitrosylated or nitrosated at a variety of naturally susceptible or artificially provided binding sites for nitric oxide or derivatives which donate or release NO.

One group of such NO adducts is the S-nitrosothiols, which are compounds that include at least one -S-NO group. Such compounds include S-nitroso-polypeptides (the term "polypeptide" includes proteins and also polyamino acids that do not possess an ascertained biological function, and derivatives thereof); S-nitrosylated amino acids (including natural and synthetic amino acids and their stereoisomers and racemic mixtures and derivatives thereof); S-nitrosylated sugars, S-nitrosylated-modified and unmodified oligonucleotides (preferably of at least 5, and more particularly 5-200, nucleotides); and an S-nitrosylated hydrocarbons where the hydrocarbon can be a branched or unbranched, and saturated or unsaturated aliphatic hydrocarbon, or an aromatic hydrocarbon; S- nitrosylated hydrocarbons having one or more substituent groups in addition to the S- nitroso group; and heterocyclic compounds. S-nitrosothiols and the methods for preparing them are described in U.S. Patent No. 5,380,758; Oae *et al.*, Org. Prep. Proc. Int., 15(3):165-198 (1983); Loscalzo *et al.*, J. Pharmacol. Exp. Ther., 249(3):726729 (1989) and Kowaluk *et al.*, J. Pharmacol. Exp. Ther., 256:1256-1264 (1990), all of which are incorporated in their entirety by reference.

One particularly preferred embodiment of this aspect relates to S-nitroso amino acids where the nitroso group is linked to a sulfur group of a sulfur-containing amino acid or derivative thereof. For example, such compounds include the following: S-nitroso-N-acetylcysteine, S-nitroso-captopril, S-nitroso-homocysteine, S-nitroso-cysteine and S-nitroso-glutathione.

Suitable S-nitrosylated proteins include thiol-containing proteins (where the NO group is attached to one or more sulfur group on an amino acid or amino acid derivative thereof) from various functional classes including enzymes, such as tissue-type plasminogen activator (TPA) and cathepsin B; transport proteins, such as lipoproteins, heme proteins such as hemoglobin and serum albumin; and biologically protective proteins, such as the immunoglobulins and the cytokines. Such nitrosylated proteins are described in PCT Publ. Applic. No. WO 93/09806, published May 27, 1993. Examples include polynitrosylated albumin where multiple thiol or other nucleophilic centers in the protein are modified.

Further examples of suitable S-nitrosothiols include those having the structures:

(i)$CH_3[C(R_e)(R_f)]_xSNO$

wherein x equals 2 to 20 and R_e and R_f are as defined above;

(ii)$HS[C((R_e)(R_f)]_xSNO$

wherein x equals 2 to 20; and R_e and R_f are as defined above:

(iii)$ONS[C(R_e)(R_f)]_xB$; and

(iv)$H_2N\text{-}(CO_2H)\text{-}(CH_2)_x\text{-}C(O)NH\text{-}C(CH_2SNO)\text{-}C(O)NH\text{-}CH_2\text{-}CO_2H$

wherein x equals 2 to 20; R_e and R_f are as defined above; and B is selected from the group consisting of fluoro, C_1-C_6 alkoxy, cyano, carboxamido, cycloalkyl, arylakoxy, alkylsulfinyl, arylthio, alkylamino, dialkylamino, hydroxy, carbamoyl, N-alkylcarbamoyl, N,N-dialkylcarbamoyl, amino, hydroxyl, carboxyl, hydrogen, nitro and aryl.

Nitrosothiols can be prepared by various methods of synthesis. In general, the thiol precursor is prepared first, then converted to the S-nitrosothiol derivative by nitrosation of the thiol group with $NaNO_2$ under acidic conditions (pH is about 2.5) to yield the S-nitroso derivative. Acids which may be used for this purpose include aqueous

sulfuric, acetic and hydrochloric acids. Alternatively, the precursor thiol may be nitrosylated by treatment with an alkyl nitrite such as tert-butyl nitrite.

Another group of such NO adducts are those wherein the compounds donate, transfer or release nitric oxide and are selected from the group consisting of compounds that include at least one ON-N- or ON-C- group. The compound that includes at least one ON-N- or ON-C- group is preferably selected from the group consisting of ON-N- or ON-C-polypeptides (the term "polypeptide" includes proteins and also polyamino acids that do not possess an ascertained biological function, and derivatives thereof); ON-N- or ON-C-amino acids(including natural and synthetic amino acids and their stereoisomers and racemic mixtures); ON-N- or ON-C-sugars; ON-N- or ON-C-modified and unmodified oligonucleotides (preferably of at least 5, and more particularly 5-200, nucleotides). ON- O-, ON-N- or ON-C-hydrocarbons which can be branched or unbranched, saturated or unsaturated aliphatic hydrocarbons or aromatic hydrocarbons: ON-N- or ON-C- hydrocarbons having one or more substituent groups in addition to the ON-N- or ON-C- group; and ON-N- or ON-C-heterocyclic compounds.

Another group of such NO adducts is the nitrites which have an -O-NO group wherein the organic template to which the nitrite group is appended is a protein, polypeptide, amino acid, carbohydrate, branched or unbranched and saturated or unsaturated alkyl, aryl or a heterocyclic compound. A preferred example is the nitrosylated form of isosorbide. Compounds in this group form S-nitrosothiol intermediates *in vivo* in the recipient human or other animal to be treated and can therefore include any structurally analogous precursor R-O-NO of the S-nitrosothiols described above.

Another group of such adducts are nitrates which donate, transfer or release nitric oxide and are selected from the group consisting of compounds that include at least one at least one O_2N-O-, O_2N-N-, O_2N-S- or O_2N-C- group. Preferred among these are those selected from the group consisting of O_2N-O-, O_2N-N-, O_2N-S- or O_2N-C- polypeptides; O_2N-O-, O_2N-N-, O_2N-S- or O_2N-C-amino acids; O_2N-O-, O_2N-N- O_2N- S- or O_2N-C-sugars; O_2N-O-, O_2N-N-, O_2N-S- or O_2N-C-modified and unmodified oligonucleotides; O_2N-O-, O_2N-N-, O_2N-S- or O_2N-C- hydrocarbons which can be branched or unbranched, saturated or unsaturated aliphatic hydrocarbons or aromatic hydrocarbons:

O_2N-O-, O_2N-N-, O_2N-S- or O_2N-C- hydrocarbons having one or more substituent groups in addition to the O_2N-O-, O_2N-N-, O_2N-S- or O_2N-C-group; and O_2N-O-, O_2N-N-, O_2N-S- or O_2N-C-heterocyclic compounds. Preferred examples are isosorbide dinitrate and isosorbide mononitrate.

Another group of such NO adducts is the nitroso-metal compounds which have the structure $(R)_n$-A-M-$(NO)_x$. R includes polypeptides (the term "polypeptide" includes proteins and also polyamino acids that do not possess an ascertained biological function, and derivatives thereof); amino acids (including natural and synthetic amino acids and their stereoisomers and racemic mixtures and derivatives thereof); sugars; modified and unmodified oligonucleotides (preferably of at least 5, and more particularly 5-200, nucleotides); and a hydrocarbon where the hydrocarbon can be a branched or unbranched, and saturated or unsaturated aliphatic hydrocarbon, or an aromatic hydrocarbon; hydrocarbons having one or more substituent groups in addition to the A-nitroso group; and heterocyclic compounds. A is S, O, or N; n and x are each integers independently selected from 1, 2 and 3, and M is a metal, preferably a transition metal. Preferred metals include iron, copper, manganese, cobalt, selenium and luthidium. Also contemplated are N-nitrosylated metal centers such as nitroprusside.

Another group of such adducts are N-oxo-N-nitrosoamines which donate, transfer or release nitric oxide and have a R_1R_2-N(O-M^+)-NO group wherein R_1 and R_2 include polypeptides, amino acids, sugars, modified and unmodified oligonucleotides, hydrocarbons where the hydrocarbon can be a branched or unbranched, and saturated or unsaturated aliphatic hydrocarbon or an aromatic hydrocarbon, hydrocarbons having one or more substituent groups and heterocyclic compounds. M^+ is a metal cation, such as, for example, a Group I metal cation.

Another group of such adducts are thionitrates which donate, transfer or release nitric oxide and have the structure R_{10}-S-NO_2 wherein R_{10} is as described above for the N-oxo-N-nitrosoamines.

Agents which stimulate endogenous NO synthesis such as L-arginine, the substrate for nitric oxide synthase, are also suitable for use in accordance with the invention.

When administered *in vivo*. the nitric oxide may be administered in combination with pharmaceutical carriers and in dosages described herein.

In another aspect the invention provides a method of treating male impotence in an individual in need thereof by administering to the individual a therapeutically effective amount of a composition comprising a nitrosated or nitrosylated α–antagonist of the invention in a pharmaceutically acceptable carrier.

In another aspect the invention provides a method of treating male impotence in an individual in need thereof which comprises treating an individual for male impotence by administering to the individual a therapeutically effective amount of a composition comprising an α–adrenergic receptor antagonist (α–antagonist). which can optionally be substituted with at least one NO or NO_2 moiety. and a compound that donates. transfers or releases nitric oxide in a pharmaceutically acceptable carrier.

Total daily dose administered to a host in single or divided doses may be in amounts. for example. from about 1 to about 100 mg/kg body weight daily and more usually about 3 to 30 mg/kg. Dosage unit compositions may contain such amounts of submultiples thereof to make up the daily dose.

The amount of active ingredient that may be combined with the carrier materials to produce a single dosage form will vary depending upon the host treated and the particular mode of administration.

The dosage regimen for treating a disease condition with the compounds and/or compositions of this invention is selected in accordance with a variety of factors. including the type. age. weight. sex. diet and medical condition of the patient. the severity of the disease. the route of administration. pharmacological considerations such as the activity, efficacy, pharmacokinetic and toxicology profiles of the particular compound employed. whether a drug delivery system is utilized and whether the compound is administered as part of a drug combination. Thus. the dosage regimen actually employed may vary widely and therefore may deviate from the preferred dosage regimen set forth above.

The compounds of the present invention may be administered orally, parenterally or topically in dosage unit formulations containing conventional nontoxic pharmaceutically acceptable carriers, adjuvants, and vehicles as desired. Topical administration may also involve the use of transdermal administration such as transdermal patches or iontophoresis devices. The term parenteral as used herein includes subcutaneous injections, intravenous, intramuscular, intrasternal injection, or infusion techniques.

Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions may be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation may also be a sterile injectable solution or suspension in a nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1, 3-butanediol. Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution, and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed an a solvent or suspending medium. For this purpose any bland fixed oil may be employed including synthetic mono- or diglycerides, in addition, fatty acids such as oleic acid find use in the preparation of injectables.

Solid dosage forms for oral administration may include capsules, tablets, pills, powders, granules and gels. In such solid dosage forms, the active compound may be admixed with at least one inert diluent such as sucrose lactose or starch. Such dosage forms may also comprise, as in normal practice, additional substances other than inert diluents, e.g., lubricating agents such as magnesium stearate. In the case of capsules, tablets, and pills, the dosage forms may also comprise buffering agents. Tablets and pills can additionally be prepared with enteric coatings.

Liquid dosage forms for oral administration may include pharmaceutically acceptable emulsions, solutions, suspensions, syrups, and elixirs containing inert diluents commonly used in the art, such as water. Such compositions may also comprise adjuvants, such as wetting agents, emulsifying and suspending agents, and sweetening, flavoring, and perfuming agents.

While the compounds of the invention can be administered as the sole active

pharmaceutical agent, they can also be used in combination with one or more compounds which are known to be effective against the specific disease state that one is targeting for treatment. The compositions of the invention can be administered as a mixture of an α-antagonist and a nitric oxide donor, they can also be used in combination with one or more compounds which are known to be effective against the specific disease state that one is targeting for treatment.

The invention also provides a pharmaceutical pack or kit comprising one or more containers filled with one or more of the ingredients of the pharmaceutical compositions of the invention. Associated with such container(s) can be a notice in the form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products, which notice reflects approval by the agency of manufacture, use or sale for human administration.

Example 1

N-(N-L-g-glutamyl- S-Nitroso-L-cysteinyl)glycine

N-(N-L-g-glutamyl-L-cysteinyl)glycine (100 g, 0.325 mol) was dissolved in deoxygenated water (200 ml) and 2N HCl (162 ml) at room temperature and then the reaction mixture was cooled to 0°C. With rapid stirring, a solution of sodium nitrite (24.4 g, 0.35 mol) in water (40 ml) was added. Stirring with cooling of the reaction mixture was continued for approximately 1 hour after which time the pink precipitate which formed was collected by vacuum filtration. The filter cake was resuspended in chilled 40% acetone-water (600 ml) and collected by vacuum filtration. The filter cake was washed with acetone (2 X 200 ml) and ether (100 ml) and then dried under high vacuum at room temperature in the dark to afford the title compound as a pink powder. ^{1}H NMR (D_2O) : 1.98 (m, 2H), 2.32 (t, 2H), 3.67 (t, 1H), 3.82 (s 2H), 3.86 (dd, 1H), 3.98 (dd, 1H), 4.53 (m, 1H).

Example 2

2-Acyl-17α(3-methyl-3-nitrosothiolbutoxy)yohimban-16α–carboxylic acid methyl ester hydrochloride salt

2a. 3-Methyl-3(2-tetrahydropyranyl)thiobutyric acid

3-Methyl-3-thiobutyric acid (4.2 g, 31 mmol), dihydropyran (2.8 ml, 31 mmol), and 200 µl of 4 N HCl/Et_2O were allowed to stand at room temperature overnight. The volatiles were evaporated *in vacuo* (2 mm Hg) yielding 6.6 g (30 mmol) of material which was used without further purification. ^{1}H-NMR ($CDCl_3$): 4.92 (d, J = 8.1 Hz, 1H), 4.09 (d, J = 10.5 Hz, 1H), 3.49-3.56 (mult, 1H), 2.73 (dd, J = 1.2 and 13.7 Hz, 1H), 2.64 (d, J = 13.8 Hz, 1H), 1.84-1.89 (mult 2H), 1.55-1.69 (mult, 4H), 1.51(s, 3H), 1.42 (s, 3H).

2b. 3,3'-Dimethyl-3,3'(2-ditetrahydropyranyl)thiobutyric acid anhydride

The product of Example 2a (1.1 g, 5 mmol) and triethylamine (710 µl, 5 mmol) was dissolved in ethyl acetate (50 ml) and cooled to 0° C. Triphosgene (250 mg, 0.85 mmol) was added all in one portion and the reaction was stirred at 0° C for 15 minutes then warmed to room temperature with continued stirring for 30 minutes. The precipitate which formed was removed by filtration and the filtrate was concentrated by rotary evaporation to afford 1.0 g (5 mmol) of the title compound. ^{1}H-NMR ($CDCl_3$): 5.03-5.06 (mult, 2H), 4.04-4.08 (mult, 2H), 3.46-3.51 (mult, 2H), 2.89 (d, J = 15.7 Hz,

2H). 2.77 (d. J = 15.6 Hz. 2H), 1.79-1.88 (mult. 4H). 1.51-1.67 (mult. 8H). 1.54 (s. 6H). 1.49 (s. 6H).

2c. 17a (3-methyl-3-tetrahydropyranylthiolbutoxy)yohimban-16α-carboxylic acid methyl ester

To a solution of yohimbine (1.6 g, 4.5 mmol) in pyridine (6 ml) was added the product of Example 2b (2.5 g. 6 mmol) and 4-dimethylaminopyridine (730 mg, 6 mmol). The reaction mixture was stirred at room temperature for 6 days. Acetonitrile (50 ml) was added to the reaction and then all of the volatile components were evaporated *in vacuo*. The residue was dissolved in ethyl acetate (100 ml) and washed with a 10 % solution of aqueous sodium carbonate. The aqueous wash was then back extracted once with ethyl acetate. The combined organic extracts were washed with H_20, brine, and then dried over anhydrous sodium sulfate. Treatment of the solution with activated charcoal followed by filtration and concentration of the filtrate *in vacuo* gave 2.8 g of a dark syrup.

Chromatography on silica gel eluting with 1:1 hexane/ethyl acetate containing 1% by volume triethylamine afforded 670 mg (20%) of the title compound. ^{1}H-NMR ($CDCl_3$): 7.76 (s, 1H), 7.46 (d, J = 7.2 Hz, 1H), 7.29 (dd, J = 1.0 and 7.0 Hz, 1H), 7.12 (ddd; J = 1.3, 7.1, and 7.1 Hz; 1H), 7.07 (ddd; J = 1.1, 7.2, and 7.2 Hz; 1H). 5.46 (d, J = 2.6 Hz, 1H), 5.07-5.11 (mult, 1H). 4.06-4.11 (mult, 1H), 3.69 (s, 3H), 3.47-3.55 (mult, 1H). 3.39 (d, J = 10.4 Hz, 1H), 3.02-3.12 (mult, 2H), 2.97 (dd, J = 4.5 and 12.2 Hz, 1H), 2.80 (d, J = 14.3 Hz, 1H). 2.71 (mult, 1H). 2.69 (d, J = 13.2 Hz, 1H). 2.61-2.65 (mult, 1H). 2.39 (dd, J = 2.6 and 11.6 Hz, 1H), 2.23-2.33 (mult, 2H), 1.71-2.07 (mult, 5H), 1.58-1.69 (mult, 8H). 1.51 (s, 3H). 1.49 (s, 3H). Anal Calcd for ($C_{31}H_{42}N_2O5S$-1/2 H_20): C, 66.05; H, 7.69; N, 4.97; S, 5.69. Found C, 65.74; H, 7.33; N, 4.88; S, 5.57.

2d. 2-Acyl- 17a(3 -methyl-3 -thiolbutoxy)yohimban-16α-carboxylic acid methyl ester

The product of Example 2c (620 mg, 1.1 mmol) was refluxed in a mixture of acetic acid (5 ml) and acetyl chloride (5 ml) for 4 hours. The solvent was evaporated *in vacuo* (2 mm Hg). The residue was partitioned between 5% aqueous ammonium hydroxide and ethyl acetate. The aqueous wash was extracted with ethyl acetate. The combined organic extracts were washed with brine and dried over anhydrous sodium sulfate. The solvent was evaporated *in vacuo* and the residue was chromatographed on silica gel eluting with 1:1 hexane/ethyl acetate containing 1% by volume triethylamine to

afford 210 mg (34 %) of 2-acyl-17α.(3-methyl-3-thioacetylbutoxy)yohimban-16 α–carboxylic acid methyl ester. This diacetate (180 mg. 0.32 mmol) was dissolved in acetic acid (4 ml) to which was added mercuric trifluoroacetate (190 mg. 0.45 mmol) and the reaction mixture was stirred at room temperature for 2 hours. The volatiles were evaporated *in vacuo* leaving a gum which was triturated with 1N HCl (6 ml) to afford a yellow powder. The powder was partitioned between ethyl acetate and 10% aqueous ammonium hydroxide. The organic phase was filtered through Celite to remove the gray solid which was present and then the filtrate was washed with brine and then dried over anhydrous sodium sulfate.

Evaporation of the volatiles *in vacuo* afforded a solid which was chromatographed on silica gel eluting with a gradient of with 1:1 hexane/ethyl acetate containing 1% by volume triethylamine to ethyl acetate containing 1 % by volume triethylamine to yield 60 mg (37 %) of the title compound as a white powder. ^{1}H-NMR ($CDCl_3$): 7.81 (d. J = 7.0 Hz. 1H). 7.41 (d. J = 6.8 Hz. 1H). 7.23-7.29 (mult. 2H). 5.46 (s. 1H). 4.17 (d. J = 9.9 Hz. 1H). 3.64 (s. 3H). 3.11-3.15 (mult. 1H). 3.00 (dd. J = 3.5 and 12.4 Hz. 1H). 2.64-2.84 (mult. 10H). 2.31 (dd. J = 2.6 and 11.7 Hz. 1H). 2.24 (d. J = 12.7 Hz. 1H). 2.04-2.0 8 (mult. 2H). 1.41-1.62 (mult. 11H). ^{13}C-NMR ($CDCl_3$): 171.6. 170.7. 169.5. 13 7.3. 136.4. 129.6. 124.1. 122.9. 118.3. 117.2. 114.6. 70.0. 61.0. 59.8. 51.9. 51.8. 50.9. 47.7. 45.6. 37.8. 37.6. 36.22. 36.2. 33.2. 29.9. 27.1. 23.8. 22.3.

2e. 2-Acyl-17a(3-methyl-3-nitrosothiolbutoxy)yohimban-16α–carboxylic acid methyl ester hydrochloride salt

To a slurry of the compound of Example 2d (40 mg. 0.078 mmol) in 1:1 methanol/1N HCl (4 ML) with dimethylformamide (400 µl) was added a solution of sodium nitrite (11 mg. 0. 16 mmol) in H_2O (200 µl). The white powder turned green as the slurry was stirred at room temperature for 25 minutes. At this juncture dimethylformamide (600 µl) and additional aqueous sodium nitrite (11 mg in 200 µl of H_2O) was added and stirring at room temperature was continued for an additional 15 minutes. The reaction mixture was partitioned between $CHCl_3$ and H_2O adding 10% aqueous ammonium hydroxide to the aqueous phase until basic to pH paper. The aqueous layer was extracted with $CHCl_3$ and the combined organic extracts were washed with brine and then dried over anhydrous sodium sulfate. The volatiles were evaporated *in vacuo* and the residue was dissolved in ether. The product was precipitated with

ethereal HCl to afford 19 mg of the title compound as a green solid. ^{1}H-NMR ($CDCl_3$): 7.81 (dd, J = 1.7 and 6.8 Hz, 1H), 7.42 (d, J = 6.8 Hz, 1H), 7.23-7.29 (mult, 2H), 5.43 (d, J = 2.6 Hz, 1H), 4.15 (d, J = 9.8 Hz, 1H), 3.63 (s, 3H), 3.36 (d, J = 15.1 Hz, 1H), 3.30 (d, J = 15.1 Hz, 1H), 3.12 (dd, J = 4.9 and 11.0 Hz, 1H), 3.00 (dd, J = 3.7 and 12.3 Hz, 1H), 2.72 (s, 3H), 2.63 -2.82 (mult, 3H), 2.31 (dd, J = 2.6 and 11.7 Hz, 1H), 2.03 (s, 3H), 2.00 (s, 3H), 1.0-2.0 (mult, 9H).

Example 3

2-{[ß-(4-(3-S-Nitroso-3-methyl-butyric acid)phenyl) ethyl]aminomethyl}-1-tetralone ester hydrochloride

3a. 2-{[ß-(4-Hydroxyphenyl) ethyl] t-butoxycarbonylaminomethyl}-1-tetralone

2-{[ß-4-Hydroxyphenyl) ethyl] aminomethyl}-1-tetralone (3.39 g, 11.5 mmol) was dissolved in dichloromethane (50 mL) and di-tert-butyldicarbonate (2.50 g, 11.5 mmol) was added. The reaction mixture was stirred for 100 minutes at room temperature. The solvent was evaporated, and the residue was purified by flash chromatography on silica-gel, eluting with hexane/ethyl acetate (3:1) to give 2.32 g (51 %) of the title compound . ^{1}H NMR ($CDCl_3$, 300 MHz) 1.44 (s, 9 H), 1.61-1.89 (m, 1 H), 2.15-2.29 (m, 1 H), 2.50-2.85 (m, 4 H), 2.90-3.08 (m, 2 H), 3.29-3.45 (m, 3 H), 3.49-3.64 (m, 1 H), 6.76 (d, 2 H), 7.04 (d, 2 H), 7.19-7.32 (m, 2 H), 7.39-7.50 (m, 1 H), 8.01 (d, 1 H).

3b. 2-{[ß-(4-(3-Tetrahydropyranylthio-3-methyl-butyric acid)phenyl) ethyl]aminomethyl}-1-tetralone ester

The product of Example 3a (0.300 g, 0.76 mmol) was dissolved in pyridine (0.5 mL) and a solution of the product of Example 2b (0.397 g, 0.95 mmol) in pyridine (0.5 mL) was added. The resulting solution was stirred for 18 hours at room temperature. The solvent was evaporated, and the residue was purified by flash chromatography on silica-gel, eluting with hexane/ethyl acetate (4:1) to give 0.332 g (73 %) of the title compound. ^{1}H NMR ($CDCl_3$, 300 MHz) _1.44 (s, 9 H), 1.56 (d, 6 H), 1.52-1.78 m, 6 H), 1.66-1.97 (m, 1 H), 2.16-2.31 (m, 1 H), 2.73- 3.06 (dd, overlapping with multiplet, 7H), 3.33-3.67 (m, 5 H), 4.05-4.17 (m, 1 H), 5.09-5.17 (m, 1 H), 7.01 (d, 2 H), 7.13-7.36 (m, 4 H), 7.47 (t, 1 H), 8.01 (d, 1 H).

3c. 2-{[ß-(4-(3-Mercapto-3-methyl-butyric acid)phenyl) ethyl]-t-buyoxycarbonyl-aminomethyl}-1-tetralone ester

The product of Example 3b (0.192 g. 0.32 mmol) was dissolved in methanol (2 mL) and a solution of silver nitrate (0.117g. 0.69 mmol) in water (0.4 mL) was added. The resulting mixture was stirred for 1 hour at room temperature. The solvent was evaporated. the residue was suspended in acetone/water (1:10) and 1N HCl (1 mL) was added. After stirring for 18 hours at room temperature, the precipitate was filtered and filtrate was extracted with dichloromethane. The organic layer was washed with brine. dried over anhydrous sodium sulfate and concentrated in vacuo to give 0.085 g (51 %) of the title compound . ^{1}H NMR ($CDCl_3$, 300 MHz) _1.44 (s. 9 H). 1.58 (d. 6 H). 1.73-1.96 (m. 1 H). 2.17-2.31 (m. 1 H). 2.38 (s. 1 H). 2.64-2.93 (m. 5 H). 2.94-3.07 (m. 2 H). 3.45 (t. 3 H). 3.58-3.67 (m. 1 H). 7.02 (d. 2 H). 7.15-7.36 (m. 4 H). 7.47 (t. 1 H). 8.01 (d. 1 H).

3d. 2-{[ß-(4-(3-Mercapto-3-methyl-butyric acid)phenyl) ethyl]aminomethyl}-1-tetralone ester

The product of Example 3c (0.149 g. 0.29 mmol) was dissolved in dichloromethane (3 mL) and trifluoroacetic acid (3 mL) was added. The resulting solution was stirred for 15 minutes at room temperature. The solvent was evaporated. and the residue was dissolved in dichloromethane (10 mL). Water (5 mL) was added and pH was made basic with saturated sodium bicarbonate solution. Organic layer was separated and aqueous fraction was extracted with dichloromethane. The combined organic phase was washed with brine. dried over anhydrous sodium sulfate and concentrated in vacuo to give 0.098 g (82 %) of the title compound. ^{1}H NMR ($CDCl_3$, 300 MHz) 159 (s. 6 H), 1.84-2.03 (m. 1 H). 2.15-2.26 (m. 1 H). 2.39 (s. 1 H). 2.82- 3.16 (m, 11 H). 7.06 (d. 2 H). 7.18-7.35 (m. 4 H). 7.49 (t. 1 H). 8.00 (1 H).

3e. 2-{[ß-(4-(3-S-Nitroso-3-methyl-butyric acid)phenyl) ethyl]aminomethyl}-1-tetralone ester hydrochloride

The product of Example 3d (0.081 g. 0.20 mmol) was dissolved in methanol (4 mL) and 1N HCl was added. A solution of sodium nitrite (0.045 g, 0.65 mmol) in water (0.25 mL) was added. After stirring for 15 minutes at room temperature an additional sodium nitrite (0.045 g. 0.65 mmol) in water (0.25 mL) was added. The reaction mixture was stirred for 15 more minutes. and was then extracted with dichloromethane. The organic layer was dried over anhydrous sodium sulfate and the solvent was evaporated to give 0.072 g (81 %) of the title compound as a green solid. ^{1}H NMR ($CDCl_3$. 300 MHz) δ:1.72-1.93 (m. 1 H). 2.09 (s. 6 H). 2.18-2.30 (m. 1 H). 2.84-3.11 (m. 1 H). 3.14-3.33 (m.

6 H), 3.36-3.57 (m, 4 H), 7.03 (d, 2 H), 7.18-7.42 (m, 4 H), 5.53 (t, 1 H), 7.94 (d, 1 H).

Example 4

4-(2-methoxyphenyl)-α-[(1-naphthalenyloxy)methyl]-1-piperazineethyoxy-[3-S-nitroso-3-methyl-butyric acid] ester

4a. 3-Methyl-3-(2,4,6-trimethoxyphenylmethylthio)butyric acid

To a solution of 3-mercapto-3-methylbutyric acid (B.J. Sweetman et al. *J. Med Chem.*, 14, 868 (1971)) (4.6 g, 34 mmol) in methylene chloride (250 mL) under nitrogen and cooled over ice/salt to 5°C (internal temperature) was added trifluoroacetic acid (82 g, 0.72 mol). No significant temperature rise was noted during the addition. To this was then added dropwise a solution of 2,4,6-trimethoxybenzyl alcohol (M.C. Munson et al., *J. Org. Chem.*, 57, 3013 (1992)) (6.45 g, 32 mmol) in methylene chloride (150 mL) such that the reaction temperature does not rise above 5°C. After the addition was complete, the mixture was stirred for an additional 5 minutes at 5°C and the volatiles were evaporated *in vacuo* (toluene or ethyl acetate can be used to assist in the removal of volatile material). The residue was partitioned between diethyl ether and water and the organic phase dried over anhydrous sodium sulfate, filtered and the volatile material evaporated *in vacuo*. The residue was treated with activated charcoal and recrystalised from diethyl ether/hexane. The product was isolated as an white solid in 70% yield (7 g) mp 103-105 °C. ^{1}H NMR ($CDCl_3$) δ: 6.12 (s, 2H), 3.80-3.85 (m, 11 H), 2.74 (s, 2H), 1.47 (s, 6H). ^{13}C NMR ($CDCl_3$) 173.9, 160.6, 158.6, 105.6, 90.5, 55.7, 55.3, 45.9, 43.6, 28.4, 21.0.

4b. 4-(2-methoxyphenyl)-α-[(1-naphthalenyloxy)methyl]-1-piperazineethyoxy-[3-(2,4,6-trimethyoxybenzylthio)-3-methyl-butyric acid] ester

Under a nitrogen atmosphere, 4-(2-methoxyphenyl)-α-[(1-naphthalenyloxy)methyl]-1-piperazineethanol (0.130 g, 0.35 mmol) was dissolved in anhydrous dimethylformamide (2 mL) and 4-dimethylaminopyridine (0.017 g, 0.14 mmol) was added, followed by the product of Example 4a (0.211 g, 0.69 mmol) and 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide (0.132 g, 0.69 mmol). The resulting mixture was stirred 2 hours at room temperature and then 24 hours at 50°C. The solvent was evaporated *in vacuo* and the residue was purified by flash chromatography on silica gel eluting with hexane/ ethyl acetate (3:1) to (2:1) to give the title compound (0.133 g, 56 % yield). ^{1}HNMR ($CDCl_3$, 300 MHz) δ: 1.49-1.53 (d, 6 H, J = 2.42 Hz), 2.70- 2.84

(m, 8H). 2.98-3.09 (m. 4 H). 3.75-3.85 (m. 11 H). 3.86 (s. 3 H). 4.31-4.36 (m. 2 H). 5.43-5.52 (m, 1 H), 6.08 (s, 2 H). 6.81-6 86 (m. 2 H). 6.90-6.93 (m. 2 H). 6.97- 7.01 (m. 1H). 7.33-7.7- (m. 4 H). 7.77-7.82 (m, 1 H). 8.23-8.27 (m. 1 H).

4c. 4-(2-methoxyphenyl)-α-[(1-naphthalenyloxy)methyl]-1-piperazineethyoxy-[3-mercapto-3-methyl-butyric acid] ester

The product of Example 4b (0.128 g, 0.186 mmol) was dissolved in methylene chloride (0.50mL). and then anisole (0.13 mL, 1.20 mmol). phenol (0.013 g.0.14 mmol). water (0.13 mL). and trifluoroacetic acid (0.80 mL. 10.4 mmol) were added. After 1 hour of stirring at room temperature. toluene (2 mL) was added and volatiles were evaporated. The residue was purified by flash chromatography on silica gel eluting with hexane/ ethyl acetate (2:1) to give the title compound (0.055 g, 60 % yield) as a solid. ^{1}H NMR ($CDCl_3$. 300 MHz) 1.49-1.53 (d. 6 H, J =2.42 Hz). 2.59 (s. 1 H). 2.69-2.86 (m. 8 H). 3.01-3.09 (m. 4 H). 3.86 (s. 3 H). 4.26-4.39 (m. 2 H). 5.53-5.63 (m. 1 H). 6.81-6.88 (d. 2 H. J =7.5 Hz). 6.90-6 95 (m, 2 H). 6.98-7.04 (m. 1 H), 7.34-7.40 (t. 1 H. J=7.5Hz). 7.43-7.78 (m, 3 H), 7.79-7.82 (m, 1 H). 8.23-8.26 (m, 1 H).

4d. 4-(2-methoxyphenyl)-α-[(1-naphthalenyloxy)methyl]-1-piperazineethyoxy-[3-S-nitroso-3-methyl-butyric acid] ester

The product of Example 4c (0.048 g, 0.097 mmol) was dissolved in methanol (5mL) and 1N solution of hydrochloric acid (1.5 mL) was added. The resulting mixture was cooled to 0°C and a solution of sodium nitrite 0.040 g, 0.058 mmol) in water (0.5mL) was added. After 1 hour stirring at 0°C the reaction mixture was extracted with methylene chloride. washed with brine and dried over anhydrous sodium sulfate. The solvent was evaporated *in vacuo* to give the title compound (0.045 g, 82 % yield) as a green solid. ^{1}HNMR($CDCl_3$. 300 MHz) δ: 2.00 (s. 6 H). 3.38-3.50 (m. 13 H), 3.88 (s, 3 H). 4.31-4.40 (m, 2 H). 5.91 (s. 1 H). 6.79-6.95 (m, 5 H), 7.33-7.70 (m, 4 H), 7.79- 7.82 (m. 1 H). 8.09-8.12 (m. 1 H).

Example 5

2-[4-(2-furoyl)piperazin-1-yl]-[4-(3-S-nitroso-3-methyl-butyric acid)]-6, 7-dimethyoxyquinazoline amide

5a. 2-[4-(2-Furoyl)piperazin-1-yl]-[4-(3-(2,4,6-trimethyoxybenzylthio)-3-methyl-butyric acid)]-6, 7-dimethyoxyquinazoline amide

Under a nitrogen atmosphere 2-[4-(2-furoyl)piperazin-1-yl]-amino-6. 7-dimethyoxyquinazoline (0.200 g. 0.52 mmol) was dissolved in anhydrous dimethylformamide (5 mL) and 4-dimethylaminopyridine (0.025 g. 0.21 mmol) was added. followed by the product of Example 4a (0.319 g. 1.04 mmol) and 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide (0.199 g, 1.04 mmol). The resulting mixture was stirred at 50°C for 48 hours. The solvent was evaporated *in vacuo* and the residue was purified by flash chromatography on silica gel eluting with hexane/ethyl acetate (3:1) to (1:5) to give 0.072 g (20 % yield) of the title compound as a white solid. ^{1}H NMR ($CDCl_3$, 300 MHz) δ: 1.52 (s, 6 H). 2.88 (s, 1 H). 2.90 (s. 2 H), 2.96 (s. 1 H). 3.56 (s.6H). 3.72 (s. 3 H), 3.90-4.01 (m, 16 H), 6.48-6.52 (dd, 1 H, J = 1.69 and 3.32 Hz). 6.94 (s. 1 H), 7.01-7.05 (d. 1 H, J = 3.45 Hz), 7 19 (s, 1 H), 7.50-7.53 (m. 1 H).

5b. 2-[4-(2-Furoyl)piperazin-1-yl]-[4-(3-mecapto-3-methyl-butyric acid)]-6. 7-dimethyoxyquinazoline amide

The product of Example 5a (0.160 g, 0.24 mmol) was dissolved in methylene chloride (0.67 mL). and then anisole (0.16 mL. 1.47 mmol). phenol (0.007 g. 0.047 mmol). water (0.16 mL). and trifluoroacetic acid (0.67 mL, 8.63 mmol) were added. After 45 minutes of stirring at room temperature toluene (5 mL) was added and volatiles were evaporated. The residue was purified by flash chromatography on silica gel eluting with methylene chloride/ methanol (30:1) to (15:1) to give the title compound (0.043 g. 36 % yield) as a solid. ^{1}H NMR ($CDCl_3$, 300 MHz) δ: 1..58 (s. 6 H), 2.45 (s, 1 H). 3.00 (s.2H). 3.87-3.94 (d. 6 H. J = 6.28 Hz). 3.92-4.06 (m, 8 H). 6.53-6.57 (dd. 1 H. J=1.68 and 3.41 Hz). 6.98 (s. 1 H). 7.15-7.18 (d. 1 H. J = 3.48 Hz). 7.49 (s. 1 H). 7.54-7.59 (m. 1 H).

5c. 2-[4-(2-Furoyl)piperazin-1-yl]-[4-(3-S-nitroso-3-methyl-butyric acid)]-6. 7-dimethyoxyquinazoline amide

The product of Example 5b (0.036 g, 0.080 mmol) was dissolved in methanol and 1N solution of hydrochloric acid (1 mL) was added. The resulting mixture was cooled to 0°C and a solution of sodium nitrite (0.067 g. 0.97 mmol) in water (0.5 mL) was added. After 40 min. stirring at 0°C the reaction mixture was extracted with methylene chloride. washed with brine and dried over anhydrous sodium sulfate. The solvent was evaporated *in vacuo* to give the title compound (0.023 g. 55 % yield) as a green solid. ^{1}HNMR($CDCl_3$, 300 MHz) δ: 2.12 (s. 6 H), 3.49 (s. 2 H). 3.85-3.99 (m. 14 H). 6.51-6.55 (dd. 1H. J = 1.74 and 3.45 Hz). 6.79-6.98 (m. 2 H). 7.06-7.09 (d. 1 H. J = 3.23 Hz). 7.54-

7.58 (m. 1 H).

Example 6

4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-(3-S-nitroso-3-methyl-butyric acid) ester

6a. 4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol

4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol acetate ester (1.00 g. 3.20 mmol) was dissolved in methanol (10 mL) and sodium hydroxide (0.317 g. 7.92 mmol) was added. The reaction mixture was stirred at room temperature for 10 minutes. diluted with ethyl ether (10 mL) and washed with sodium bicarbonate solution. The organic layer was dried over anhydrous sodium sulfate. filtered and concentrated *in vacuo* to give the title compound (0.71 g. 93 % yield) as a white solid. ^{1}H NMR ($CDCl_3$. 300 MHz) δ: 1.10-1.13 (d. 6 H. J = 6.9 Hz). 2.19 (s. 3 H). 2.41 (s. 6 H). 2.80-2.85 (t. 2 H. J = 5.9 Hz). 3.19-3.26 (m. 1 H). 4.02-4.07 (t. 2 H. J=5.9Hz). 6.57- 6.59 (d. 2 H. J = 3.72 Hz).

6b. 4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-[3-(2,4,6-trimethyoxybenzylthio)] -3-methyl-butyric acid) ester

Under a nitrogen atmosphere, the product of Example 6a (0.270 g. 1.14 mmol) was dissolved in anhydrous dimethylformamide (2 mL) and 4-dimethylaminopyridine (0.028g. 0.23 mmol) was added, followed by the product of Example 4a (0.418 g. 1.36 mmol) and 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide (0.260 g. 1.36 mmol). The resulting mixture was stirred at 55°C for 24 hours. The solvent was evaporated *in vacuo* and the residue was purified by flash chromatography on silica gel. eluting with methylene chloride/ methanol (20:1) to give 0.232 g (39 % yield) of the title compound. ^{1}H NMR ($CDCl_3$. 300 MHz) δ: 1.14-1.18 (d. 6 H. J = 6.9 Hz). 1.59 (s. 6 H). 2.15 (s. 3 H). 2.35 (s. 6 H). 2.72-2.77 (t. 2 H. J = 5.9 Hz). 2.93-2.96 (m. 2 H). 3.23-3.28 (m. 1 H). 3.74-4.02 (m. 11 H). 4.03-4.07 (t. 2 H. J = 5.9 Hz). 6.11 (s. 2H). 6.67 (s. 1H). 6.81 (s. 1 H).

6c. 4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-(3-mercapto-3-methyl-butyric acid) ester

The product of Example 6b (0.220 g. 0.42 mmol) was dissolved in methylene chloride (0.30mL) and anisole (0.22 mL. 2.02 mmol). phenol (0.022 g. 0.23 mmol). water (0.22 mL) and trifluoroacetic acid (1.0 mL. 13.0 mmol) were added. After 1 hour of

stirring at room temperature. toluene (5 mL) was added and volatiles were evaporated. The residue was purified by flash chromatography on silica gel. eluting with methylene chloride/ methanol (20:1) to give the title compound (0.095 g. 64 % yield). ^{1}H NMR ($CDCl_3$. 300 MHz) δ: 1.14-1.16 (d. 6 H. J = 6.9 Hz). 1.58 (s. 6 H). 2.14 (s. 3 H). 2.40 (s. 1 H). 2.87-2.94 (m. 8 H). 3.14-3.20 (m. 1 H). 3.50-3.53 (m. 2 H). 4.31-4.34 (m. 2H). 6.67 (s. 1H). 6.84 (s. 1 H).

6d. 4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-(3-S-nitroso-3-methyl-butyric acid) ester

The product of Example 6c (0.035 g, 0.10 mmol) was dissolved in methanol (5mL) and 1N solution of hydrochloric acid (1 mL) was added. The resulting mixture was cooled to 0°C and a solution of sodium nitrite (0.014 g, 0.20 mmol) in water (0.7 mL) was added. After 20 minutes stirring at 0°C. an additional sodium nitrite (0.032 g. 0.46mmol) in water (0.7 mL) was added and the resulting mixture was stirred for 30 minutes. The reaction mixture was extracted with methylene chloride. washed with brine and dried over anhydrous sodium sulfate. The solvent was evaporated *in vacuo* to afford the product (0.028 g. 67% yield) as a green solid. ^{1}HNMR ($CDCl_3$. 300MHz) δ: 1.13-1.17 (d. 6 H. J = 6.9 Hz). 2.08-2.11 (m. 9 H). 2.95 (s. 6 H). 3.13-3.20 (m, 1 H). 3.45-3.51 (m. 4 H). 4.43-4.46 (m. 2 H). 6.23 (s. 1 H). 6.70 (s. 1 H). 6.76 (s. 1 H).

Example 7

3-[[4,5-Dihydro-1-(3-S-nitroso-3-methyl butyloxy)-imidazol-2-yl)methyl](4-methylphenyl)amino]phenol-(3-S-nitroso-3-methyl-butyric acid) ester

7a. 3-Mercapto-3-methyl butyl acetate

3-Mercapto-3-methyl butanol (Sweetman et al. *J. Med. Chem.* 14. 868 (1971) (5 g. 42 mmol) and pyridine (3.6 mL. 43 mmol) were dissolved in methylene chloride (50 mL) and cooled to -78°C. Acetyl chloride (3.1 mL. 43 mmol) was added dropwise. The solution was kept cold for 30 min then allowed to warm to room temperature. Stirring was continued for 1.5 hr. The reaction mixture was diluted with methylene chloride, washed with 1 N HCl and brine. and dried over sodium sulfate. Evaporation of the solvent gave 6.6 g of the title compound which was used without further purification. ^{1}H-NMR ($CDCl_3$) δ: 4.25 (t. J = 7.1 Hz. 2H). 2.21 (s, 1H). 2.03 (s. 3H). 1.92 (t. J = 7.2 Hz. 2H). 1.41 (s, 3H).

7b. 3-Tetrahydropyranylthio -3-methyl butyl acetate

The product of Example 7a (6.6 g. 41 mmol). dihydropyran (4 mL. 44 mmol). and 4 N HCl/Et_2O (1 mL) were allowed to stand at room temperature for 24 hours. The volatiles were evaporated *in vacuo* to leave the title compound as a viscous oil which was used without further purification. ^{1}H-NMR ($CDCl_3$) δ: 4.97 (dd. J = 3.4 and 6.6 Hz. 1H). 4.24 (t. J = 7.1 Hz. 2H). 4.04-4.09 (mult. 1H). 3.46-3.52 (mult. 1H). 2.03 (s. 3H). 1.93 (t. J = 7.5 Hz. 2H). 1.42-1.88 (mult. 6H). 1.37 (s. 3H). 1.36 (s. 3H).

7c. 3-Tetrahydropyranylthio-3-methyl butanol

The product of Example 7b (800 mg. 3.3 mmol) and sodium bicarbonate (1.4 g. 16 mmol) were dissolved in methanol (10 mL) and stirred at room temperature for 18 hours. The reaction mixture was diluted with ether (30 mL) to precipitate the salts and filtered through Celite. Evaportation of the solvent and chromatography on silica gel eluting with 3:1 hexane/ethyl acetate gave 340 mg (51%) of the title compound. ^{1}H-NMR ($CDCl_3$) δ: 4.92 (dd. J = 3.1 and 7.6 Hz. 1H), 4.05 (ddd; J = 4.0. 4.0. and 11.6 Hz. 1H), 3.81 (ddd; J = 6.3. 6.3. and 12.6 Hz. 1H). 3.78 (ddd; J = 6.3. 6.3. and 12.6 Hz. 1H). 3.49 (ddd; J = 3.8. 7.7. and 11.8 Hz. 1H). 1.79-1.89 (mult. 4H). 1.60-1.67 (mult. 4H). 1.56 (s. 3H). 1.55 (s. 3H). Anal calcd for $C_{10}H_{20}O_2S$: C; 58.78. H; 9.87. S; 15.69. Found C; 58.42. H: 9.73, S: 15.58.

7d. 3-[[4.5-Dihydro-1-(3-tetrahydropyranylthio-3-methyl butyloxy)-imidazol-2-yl)methyl](4-methylphenyl)amino]phenol-(3- tetrahydropyranylthio-3-methyl-butyric acid) ester

The product of Example 7c (700 mg. 3.5 mmol) was dissolved in tetrahydrofuran (5 mL) and cooled to -78°C. To this solution was added 2.5 M BuLi (1.38 mL. 3.5 mmol). and the reaction mixture was stirred at -78°C for 20 minutes. A solution of 1.93 M phosgene in toluene (3.6 mL. 7.0 mmol) was cooled to -78°C and the cold solution of lithium alkokide was rapidly cannulated into the phosgene solution. The reaction mixture was stirred at -78°C for 30 minutes and then warmed to room temperature and stirred for 2 hours. The solution was filtered through a cotton plug and concentrated to give the chloroformate as a syrup. A slurry of 3-[[4.5-dihydro-1H- imidazol-2-yl)methyl](4-methylphenyl)amino]phenol hydrochloride (500 mg. 1.6 mmol) and triethylamine (650 µL. 4.7 mmol) in methylene chloride (10 mL) was cooled to to -78°C. The chloroformate

was dissolved in methylene chloride (4 mL) and this solution was added to the slurry. The resulting reaction mixture was stirred at -78°C for 30 minutes and was then warmed to room temperature and stirred for 20 hours. The reaction mixture was diluted with methylene chloride and then washed successively with 0.1 N HCl. saturated aqueous sodium bicarbonate. and brine; followed by drying over sodium sulfate. Evaporation of the solvent and chromatography on silica gel eluting with 2:1 hexane/ethyl acetate gave 540 mg (46 %) of the title compound. ^{1}H-NMR ($CDCl_3$) δ: 7.18 (d, J = 8.6 Hz. 2H). 7.13 (d, J = 8.0 Hz, 2H), 7.12 (t, J = 8.2 Hz, 1H), 6.57-6.62 (mult, 2H). 6.51 (t. J = 2.2 Hz, 1H). 4.94-4.99 (mult, 2H), 4.89 (s, 2H), 4.38 (t, J = 7.3 Hz, 2H). 4.32 (t. J = 7.1 Hz. 2H), 4.03-4.08 (mult. 2H), 3.79 (s, 4H). 3.46-3.52 (mult, 2H). 2.32 (s, 3H). 1.51-2.05 (mult, 16H).

7e. 3-[[4.5-Dihydro-1-(3-thiol-3-methyl butyloxy)-imidazol-2-yl)methyl](4-methylphenyl)amino]phenol-(3-thiol-3-methyl-butyric acid) ester

The product of Example 7d (400 mg. 0.54 mmol). mercaptoethanol (760 µL. 10 mmol). and 4 N HCl in ether (250 µL, 1 mmol) were kept at room temperature for 24 hours. The reaction mixture was diluted with ethyl acetate and then washed with saturated aqueous sodium bicarbonate, water. and brine. and then dried over sodium sulfate. Hydrochloric acid was added and the solvent was evaporated to leave a syrup. The syrup was triturated with ethanol and ether. Decantation of the solvents and subjecting the residue to high vacuum overnight afforded 130 mg of solid. The solid was chromatographed on silica gel eluting with 3:1 hexane/ethyl acetate to give 30 mg (10 %) of the title compound. ^{1}H-NMR ($CDCl_3$) δ: 7.18 (d. J = 8.6 Hz. 2H). 7.14 (d. J = 7.9 Hz, 2H). 7.13 (t. J = 8.2 Hz. 1H). 6.61 (dd. J = 2.4 and 8.3 Hz. 1H). 6.59 (dd. J = 2.1 and 7.9 Hz. 1H). 6.52 (t. J = 2.2 Hz. 1H). 4.90 (s. 2H). 4.41 (t. J = 7.3 Hz, 2H). 4.35 (t. J = 7.0 Hz. 2H). 3.80 (s. 4H). 2.33 (s. 3H). 2.02 (t. J = 7.1 Hz. 2H). 1.97 (t. J = 7.1 Hz. 2H). 1.76 (s, 1H), 1.75 (s, 1H). 1.43 (s. 12H).

7f. 3-[[4.5-Dihydro-1-(3-S-nitroso-3-methyl butyloxy)-imidazol-2-yl)methyl](4-methylphenyl)amino]phenol-(3-S-nitroso-3-methyl-butyric acid) ester

The product of Example 7e (18 mg. 0.033 mmol) was dissolved in dimethylforamide (200 µL) and 4 N HCl in ether (25 µL, 0.1 mmol) was added. The reaction mixture was cooled to 0°C and tert-butyl nitrite (12 µL, 0.12 mmol) was added and then the reaction mixture was stirred at for 0°C for 20 minutes. The solvent was

evaporated *in vacuo* and the solid residue obtained was azetroped with chloroform to afford the title compound as a foam. ^{1}H-NMR (DMSO-d_6) δ: 7.09 (d. J = 8.0 Hz. 1H). 6.89 (d. J = 8.2 Hz. 1H), 6.61-6.72 (mult. 6H). 5.10 (br s. 2H). 4.44 (t. J = 6.7 Hz. 2H). 4.38 (t. J = 6.7 Hz. 2H), 4.00-4.10 (mult. 2H). 3.89-4.00 (mult. 2H). 2.65 (t. J = 6.5 Hz. 2H). 2.62 (t. J = 6.6 Hz. 2H). 2.30 (s. 3H), 1.92 (s, 6H). 1.89 (s. 6H).

Example 8
4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-(4-O-nitro-3-butyric acid) ester

8a. 4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-(4-bromo-butyric acid) ester

4-Bromobutyric acid (1 g. 6 mmol) and triethylamine (836ml. 6 mmol) was dissolved in ethyl acetate (40 ml) and cooled to 0 °C. Triphosgene (309 mg. 1.04 mmol) was added all in one portion and the reaction was stirred at 0 °C for 15 minutes then warmed to room temperature with continued stirring forl hour. The precipitate which formed was removed by filtration and the filtrate was concentrated by rotary evaporation to afford a light beige oil which was used without further purification. The product of Example 6a (395 mg. 1.78 mmol) was dissolved in dry acetonitrile (10 ml) and added to the preformed symmetrical anhydride. Scandium triflate (20 mg. 0.04 mmol) was added and the reaction mixture was stirred at room temperature for 2 hours after which time additional triethylamine (203 mg. 2 mmol) was added and stirring was continued for an additional 4 hours. The reaction was concentrated in vacuo and the residue partioned between ethyl acetate and phosphate buffer (pH 7.1). The organic phase was dried over sodium sulfate and the solvent evaporated in vacuo to afford a brown oil. The oil was chromatographed on silica gel eluting with 9:1 methylene chloride/methanol to give 152 mg (22 %) of the title compound as a light beige oil. ^{1}H-NMR ($CDCl_3$) δ: 6.84 (s. 1H), 6.69 (s. 1H). 4.35 (dd. J = 4.7 Hz and 4.7 Hz. 2H). 3.55 (t, J = 6.4 Hz. 2H). 3.41 (dd. J = 4.7 Hz and 4.7 Hz. 2H). 3.18 (m. 1H). 2.90 (s. 6H). 2.79 (t. J = 7.2 Hz. 2H). 2.30 (m. 2H). 2.13 (s. 3H). 1.18 (d. J = 6.9 Hz. 6H).

8b. 4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-(4-iodo-butyric acid) ester

The product of Example 8a (150 mg, 0.39 mmol), sodium iodide (116 mg, 0.77 mmol) and acetone (15 ml) were stirred at 50 °C for 3 hours. The solvent was evaporated in vacuo and the residue partioned between methylene chloride and and phosphate buffer (pH 7.1). The organic phase was dried over sodium sulfate and the solvent evaporated in vacuo to afford 131 mg of the crude title compound which was imidiately carried on to the next step. ^{1}H-NMR ($CDCl_3$) δ: 6.82 (s, 1H), 6.69 (s, 1H), 4.23 (dd, J = 5.4 Hz and 5.4 Hz, 2H), 3.32 (t, J = 6.6 Hz, 2H), 3.23 (m, 1H), 3.04 (dd, J = 5.4 Hz and 5.4 Hz, 2H), 2.72 (t, J = 7.2 Hz, 2H), 2.56 (s, 6H), 2.28 (m, 2H), 2.12 (s, 3H), 1.18 (d, J = 6.9 Hz, 6H).

8b. 4-[2-(Dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-(O-nitro-butyric acid) ester

The product of Example 8b (130 mg, 0.30 mmol) was dissolved in acetonitrile (5 ml) and silver nitrate (102 mg, 0.60 mmol) was added and the reaction mixture was left over night at tomm temperature. The reaction mixture was filtered through a PTFE membrane and the solvent evaporated in vacuo. The residue was chromatographed on silica gel eluting with 9:1 methylene chloride/methanol to give 19 mg (17 %) of the title compound as an oil which was solubilized in a small volume of ethyl acetate and precipitated by the addition of ether. mp: 105-107 °C MS: (DCI/NH_3): m/z = 369 $(M+H)^+$ ^{1}H-NMR ($CDCl_3$) δ: 6.84 (s, 1H), 6.71 (s, 1H), 4.49 (t, J = 6.2 Hz, 2H), 4.36 (dd, J = 4.5 Hz and 4.5 Hz, 2H), 3.56 (dd, J = 4.5 Hz and 4.5 Hz, 2H), 3.19 (m, 1H), 2.99 (s, 6H), 2.72 (t, J = 7.2 Hz, 2H), 2.19 (m, 1H), 2.11 (s, 3H), 1.17 (d, J = 6.6 Hz, 6H).

Example 9

In Vivo Comparative Erectile Responses

Male New Zealand white rabbits weighing 2.5 kg were used as the animal model. Animals were first relaxed with an i.m. injection of 25 mg/kg ketamine prior to anesthesia with a bolus i.v. injection of 10 mg/kg Profol and maintained with i.v. infusion at 0.5 mg/kg/min. Ventilation of the animals was performed with 1% halothane plus 0.8 L/min 0_2 and 1 L/min N_20. A 22 gauge angiocatheter was placed in the femoral artery for measurement of systemic blood pressure. A dorsal incision was made in the penis and the corpora cavernosa exposed and cannulated with a 21 gauge butterfly needle to measure intracavernosal pressure.

Drugs at various concentrations were delivered intracavernosally at a volume of 150 µl through a 25 gauge needle. A 150 µl solution of a mixture of papaverine (30 mg/kg), phentolamine (1 mg/kg) and prostaglandin El (10 µg/ml) (pap/phent/PGE1) was injected in the corpora as a standard solution for comparison with the response of yohimbine, the compound of Example 1, the compound of Example 2, and the combination of yohimbine and the compound of Example 1. This pap/phent/PGEl mixture is considered to cause a maximal erection-inducing effect.

As shown in Figure 1, yohimbine dose dependently induced erectile response in the anesthetized rabbit. A 500 µg dose of the compound of Example 1 was able to induce near maximal response relative to the standard dose of pap/phent/PGE1. A combination of the submaximal dose of yohimbine (150 µg) and the compound of Example 1 (500 µg) also induced maximum erectile response. Yohimbine at both the submaximal and maximal efficacy doses produced very short duration of action (Figure 2). The compound of Example 1 produced a much longer duration of action. The duration of action is potentiated by a combination of the compound of Example 1 and yohimbine which is longer than the sum of the duration of each of these compounds alone (Figure 2).

Figure 3 shows that the compound of Example 2 at the 500 µg dose is equipotent to the standard dose of pap/phent/PGE 1. A higher dose of the compound of Example 2 (1 mg) is at least equal to or more efficacious that the standard dose of the pap/phent/PGEl mixture. Figure 4 shows that the compound of Example 2 has the advantage of producing longer duration of action compared to yohimbine. Figure 5 demonstrates that a dose (500 µg) of the compound of Example 2 effective in the erectile response did not produce any effect on systemic blood pressure upon intracavernosal injection. However, a standard dose of the mixture of pap/phent/PGEl produced a significant decrease in systemic blood pressure upon intracavernosal injection, suggesting that the compound of Example 2 lacks this side effect.

Figure 1 shows the percent peak erectile response *in vivo* compared to that produced by 150 µl of pap/phent/PGEl (30 mg/ml: 1 mg/ml: 10 µg/ml) in the anesthetized rabbit following the intracavernosal injection of 150 µl of yohimbine (150 µg, 500 µg), the compound of Example 1 (500 µg), and a combination of yohimbine (150 µg) and the compound of Example 1 (500 µg). The ordinate is the percent response of

intracavernosal pressure relative to that produced by pap/phent/PGEl and the abscissa indicates the various drugs given.

Figure 2 shows the duration of the erectile response *in vivo* in the anesthetized rabbit upon intracavernosal administration of yohimbine (150 μg, 500 μg), the compound of Example 1 (500 μg), and a combination of yohimbine (150 μg) and the compound of Example 1 (500 μg). The ordinate indicates the various drugs given and the abscissa is the duration in minutes.

Figure 3 shows the percent peak erectile response *in vivo* compared to that produced by 150 μl of pap/phent/PGE1 (30 mg/ml: 1 mg/ml: 10 μg/ml) in the anesthetized rabbit following the intracavernosal injection of 150 gl of yohimbine (150 μg, 500 μg and 1 mg) and the compound of Example 2 (500 μg, 1 mg). The ordinate is the percent response of intracavernosal pressure relative to that produced by pap/phent/PGEl and the abscissa indicates the various doses of yohimbine and Example 2 given.

Figure 4 shows the duration of the erectile response *in vivo* in the anesthetized rabbit upon intracavernosal administration of yohimbine (150 μg, 500 μg and 1 mg) and the compound of Example 2 (500 μg and 1 mg). The ordinate indicates the various doses of yohimbine and the compound of Example 2 given and the abscissa is the duration in minutes.

Figure 5 compares the effects of intracavernosal injections of the compound of Example 2 (500 μg) and the standard mixture of pap/phent/PGEl on systemic blood pressure in the anesthetized rabbit.

Figure 6 shows the percent peak erectile response *in vivo* compared to that produced by 150 μl of pap/phent/PGE1 (30 mg/ml: 1 mg/ml: 10 μg/ml) in the anesthetized rabbit following the intracavernosal injection of moxisylyte (1 mg) and the compound of Example 6 (1 mg). The ordinate is the percent response of intracavernosal pressure relative to that produced by pap/phent/PGE1 and the abscissa indicates the dose of moxisylyte and the compound of Example 6 given.

Figure 7 shows the duration of the erectile response *in vivo* in the anesthetized

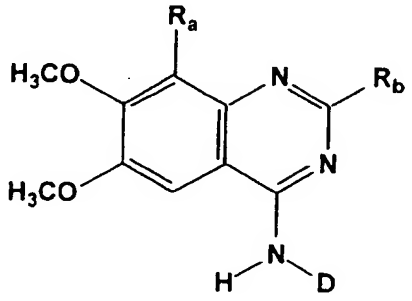
rabbit upon intracavernosal administration of moxisylyte (1 mg) and the compound of Example 6 (1 mg). The ordinate indicates the dose of moxisylyte and the compound of Example 6 the abscissa is the duration in minutes.

What Is Claimed Is:

1. Nitrosated and nitrosylated α–adrenergic receptor antagonists.

2. The nitrosated and nitrosylated α–adrenergic receptor antagonists of claim 1 selected from the group consisting of:

(i) compounds having the structure:

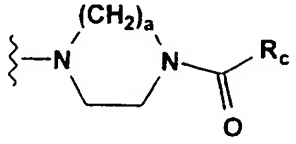


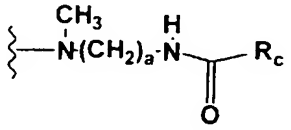
I.

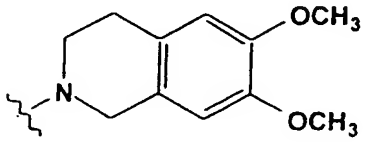
wherein,

R_a is selected from hydrogen or alkoxy;

R_b is selected from

(i) 

(ii) 

(iii) 

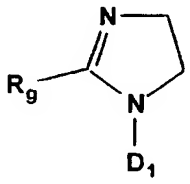
wherein

a is an integer of 2 or 3;

R_c is selected from heteroaryl, heterocyclic ring, lower alkyl, hydroxyalkyl, and arylheterocyclic ring;

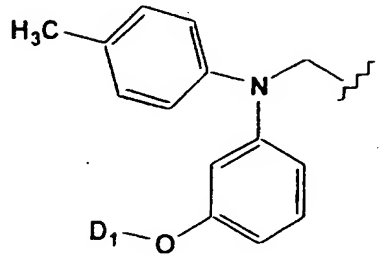
D is selected from (i) -NO; (ii) $-NO_2$; (iii) $-C(R_d)-O-C(O)-Y-Z-[C(R_e)(R_f)]_p-T-Q$ in which R_d is hydrogen, lower alkyl, cycloalkyl, aryl, alkylaryl, aryl or heteroaryl, Y is oxygen, sulfur, or NR_i in which R_i is hydrogen, lower alkyl, R_e and R_f are independently selected from hydrogen, lower alkyl, cycloalkyl, aryl, heteroaryl, arylalkyl, amino, alkylamino, amido, alkylamido, dialkylamino, carboxy, or taken together are carbonyl, cycloalkyl or bridged cycloalkyl, p is an integer from 1 to 6, T is a covalent bond, oxygen, sulfur or nitrogen, Z is selected from a covalent bond, alkyl, cycloalkyl, aryl, heteroaryl, arylalkyl or arylheterocyclic ring, and Q is selected from -NO or $-NO_2$; (iv) $-C(O)-T^1-Z-[C(R_e)(R_f)]_p-T^2-Q$ wherein T^1 and T^2 are independently selected from T and R_e, R_f, p, Q, Z, and T are as defined above; (v) $-C(O)-T[C(R_y)(R_z)]_p$ wherein R_y and R_z are independently selected from $-T^1-[C(R_e)(R_f)]_p-G-[C(R_e)(R_f)]_p-T^2-Q$ wherein G is (*i*) a covalent bond; (*ii*) -T-C(O)-; (*iii*) -C(O)-T, or (*iv*) Y, and wherein R_d, R_e, R_f, p, Q, T, and Y are as defined above:

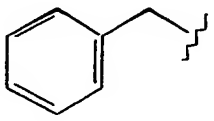
(ii) compounds having the structure:

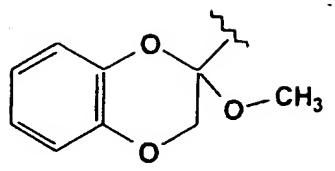


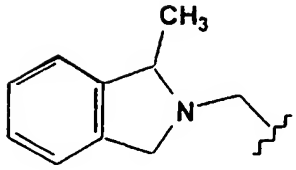
II.

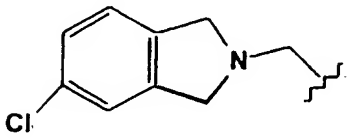
wherein, R_g is selected from:

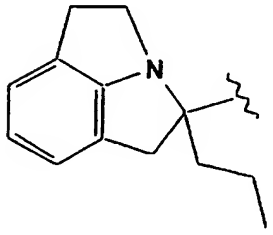
(i) 

(ii) 

(iii) 

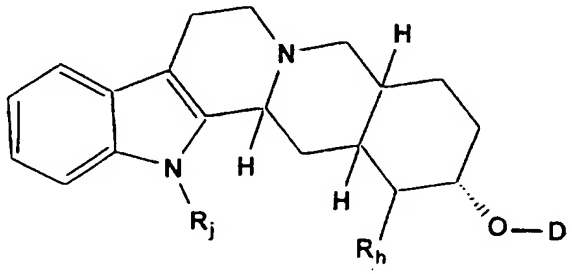
(iv) 

(v) 

(vi) 

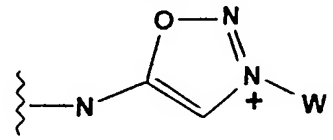
wherein D_1 is selected from hydrogen or D wherein D is as defined above and with the proviso that D_1 must be selected from D if there is no other D in the molecule:

(iii) compounds having the structure:



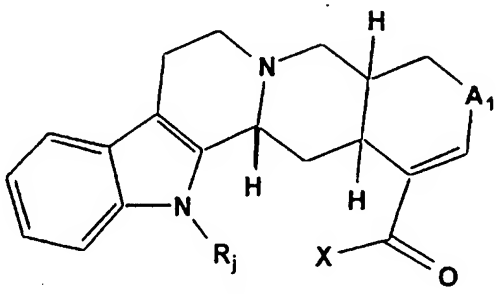
III.

wherein R_h is selected from hydrogen, $-C(O)-OR_d$ or -C(O)-X wherein X is (1) $-Y-[C(R_e)(R_f)]_p-G_i-[C(R_e)(R_f)]_p-T-Q$; wherein G_i is (i) a covalent bond; (ii) -T-C(O)-; (iii) -C(O)-T; (iv) $-C(Y-C(O)-R_m)-$ wherein R_m is heteroaryl or heterocyclic ring; and in which Y , R_d, R_e, R_f, p, Q and T are as defined above; or (2)



in which W is a heterocyclic ring or $NR_iR'_i$ wherein R_i and R'_i are independently selected from lower alkyl, aryl or alkenyl; and wherein Rj is selected from -D or $-(O)CR_d$ wherein D and R_d are as defined above;

(iv) compounds having the structure:

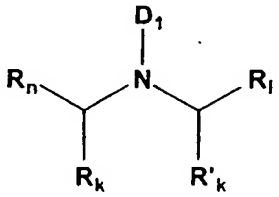


IV.

wherein,

A_1 is oxygen or methylene and X and R_j are as defined above;

(v) compounds having the structure:

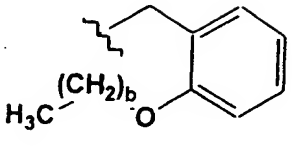


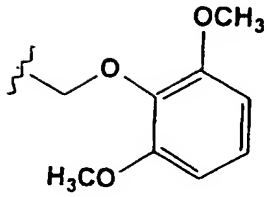
V.

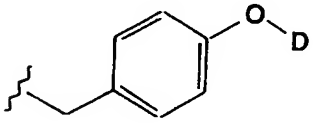
wherein

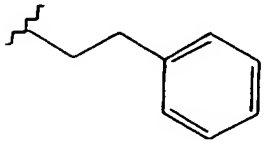
R_k and R'_k are independently selected from hydrogen or lower alkyl;

and R_1 is selected from:

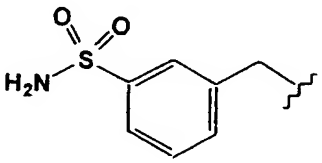
(i) 

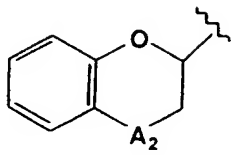
(iii) 

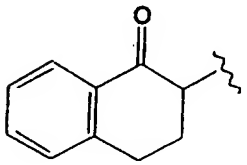
(ii) 

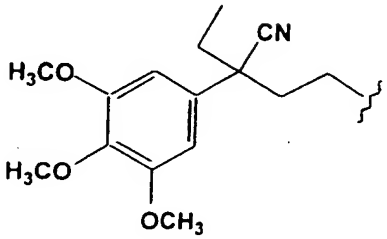
(iv) 

wherein b is an integer of 0 or 1; D_1 is as defined above: and
R_n is selected from:

(i) 

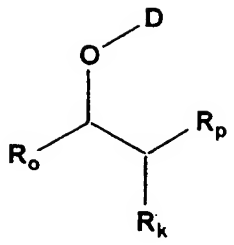
(iii) 

(ii) 

(iv) 

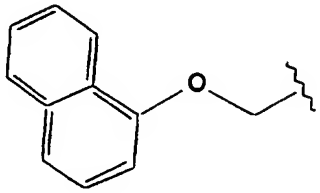
wherein A_2 is oxygen or sulfur:

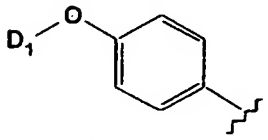
(vi) compounds having the structure:

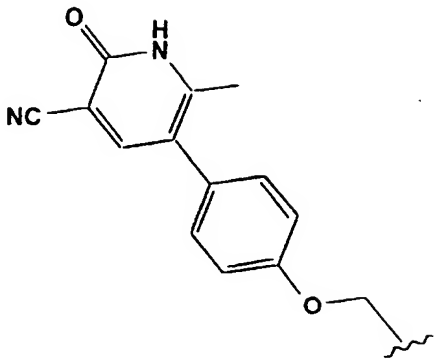


VI.

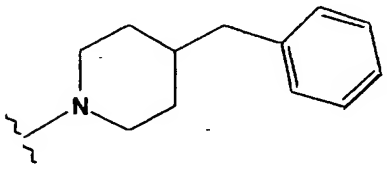
wherein R_o is selected from:

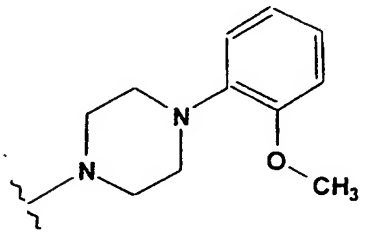
(i) 

(ii) 

(iii) 

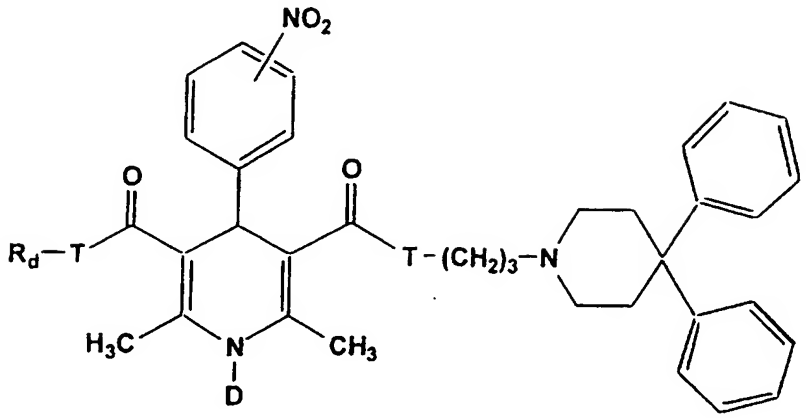
and R_p is selected from:

(i) 

(ii) 

and R_k. D and D_1 are as defined above;

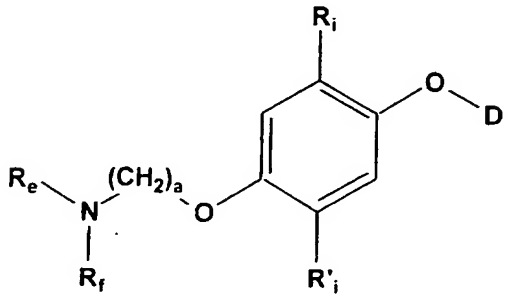
(vii) compounds having the structure:



VII.

wherein R_d, T and D are defined as above; and

(viii) compounds having the structure:



VIII.

wherein a, R_i, R'_i, R_e, R_f, and D are defined as above.

3. A composition comprising (i) a therapeutically effective amount of an α-adrenergic receptor antagonist and (ii) a compound that donates, transfers or releases nitric oxide or elevates endogenous synthesis levels of nitric oxide.

4. The composition of claim 3 wherein the α–adrenergic receptor antagonist is selected from the group consisting of haloalkylamines, imidazolines, quinazolines, indole derivatives, phenoxypropanolamines, alcohols, alkaloids, amines, piperazines and piperidines.

5. The composition of claim 4 wherein the haloalkylamine is selected from the group consisting of phenoxybenzamine and dibenamine; the imidazoline is selected from the group consisting of phentolamine, tolazoline, idazoxan, deriglidole, RX 821002, BRL 44408 and BRL 44409; the quinazoline is selected from the group consisting of prazosine, terazosin, doxazosin, alfuzosin, bunazosin, ketanserin, trimazosin and abanoquil; the indole derivative is selected from the group consisting of carvedilol and BAM 1303; the alcohol is selected from the group consisting of labetalol and ifenprodil; the alkaloid is selected from the group consisting of ergotoxine, ergocornine, ergocristine, ergocryptine, rauwolscine, corynathine, raubascine, tetrahydroalstonine, apoyohimbine, akuammigine, ß-yohimbine, yohimbol, pseudoyohimbine and epi-3α–yohimbine; the amine is selected from the group consisting of tamsulosin, benoxathian, atipamezole, tedisamil, mirtizipine, setiptiline, reboxitine, delequamine, chlorpromazine, phenothiazine, BE 2254, WB 4101 and HU-723; the piperizine is selected from the group consisting of naftopil and saterinone; and the piperidine is haloperidol.

6. The composition of claim 3 wherein the α–adrenergic receptor antagonist is selected from the group consisting of amines, amides and piperizines.

7. The composition of claim 6 wherein the amine is selected from the group consisting of tedisamil, BE 2254, HU-723, WB 4101, benoxathian, atiparnezole, mirtazipine, setiptiline, reboxitine and delequamine; the amide is selected from the group consisting of indoramin and SB 216469; and the piperizine is selected from the group consisting of SL 89.0591, ARC 239, urapidil, 5-methylurapidil and monatepil.

8. The composition of claim 3 wherein the compound that donates, transfers or releases nitric oxide is a S-nitrosothiol.

9. The composition of claim 8 wherein the S-nitrosothiol is selected from the group consisting of those having the structures:

(i) $CH_3[C(R_e)(R_f)]_xSNO$;

(ii) $HS[C(R_e)(R_f)]_xSNO$;

(iii) $ONS[C(R_e)(R_f)]_xB$; and

(iv) H_2N-(CO_2H)-$(CH_2)_x$-C(O)NH-C(CH_2SNO)-C(O)NH-CH_2-CO_2H

wherein x equals 2 to 20; R_e and R_f are independently selected from hydrogen, lower alkyl, cycloalkyl, aryl, hereroaryl, arylalkyl, alkylamino, dialkylamino or taken together are carbonyl, cycloalkyl or bridged cycloalkyl; and B is selected from the group consisting of fluoro, alkoxy, cyano, carboxamido, cycloalkyl, arylkoxy, alkylsulfinyl, arylthio, alkylamino, dialkylamino, hydroxy, carbamoyl, N-alkylcarbamoyl, N,N-dialkylcarbamoyl, amino, hydroxyl, carboxyl, hydrogen, nitro and aryl.

10. The composition of claim 3 wherein the compound that donates, transfers or releases nitric oxide is selected from the group consisting of:

(i) compounds that include at least one ON-O-, ON-N- or ON-C- group;

(ii) a N-oxo-N-nitrosoamine which has an R_1R_2-N(O-M^+)-NO group wherein R_1 and R_2 include polypeptides, amino acids, sugars, modified and unmodified oligonucleotides, hydrocarbons where the hydrocarbon can be a branched or unbranched, and saturated or unsaturated aliphatic hydrocarbon or an aromatic hydrocarbon, hydrocarbons having one or more substituent groups and heterocyclic compounds;

(iii) a thionitrate which has the structure R_{10}-S-NO_2 wherein R_{10} includes polypeptides, amino acids, sugars, modified and unmodified oligonucleotides, and a hydrocarbon where the hydrocarbon can be a branched or unbranched, and saturated or unsaturated aliphatic hydrocarbon or an aromatic hydrocarbon; and

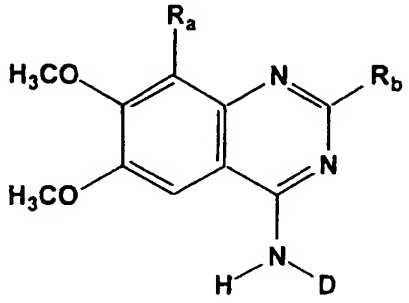
(iv) a nitrate which has the structure R_{10}-O-NO_2 wherein R_{10} is as defined above.

11. A composition comprising (i) an α–adrenergic receptor antagonist to which is directly or indirectly linked at least one nitro or nitroso group and (ii) a compound that donates, transfers or releases nitric oxide or elevates endogenous synthesis levels of nitric oxide.

12. The composition of claim 11 wherein the α–adrenergic receptor antagonist is a compound which has been nitrosated or nitrosylated through a site selected from the

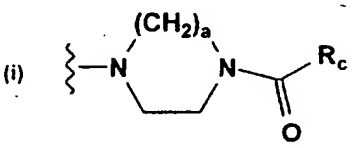
group consisting of oxygen, sulfur, carbon and nitrogen.

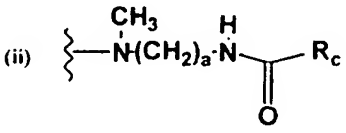
13. The composition of claim 11 wherein the nitrosated or nitrosylated α-adrenergic receptor antagonist is selected from the group consisting of:
(i) compounds having the structure:

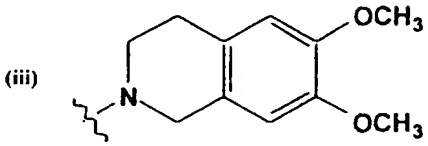


I.

wherein,
R_a is selected from hydrogen or alkoxy;
R_b is selected from







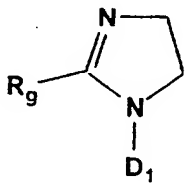
wherein

a is an integer of 2 or 3;

R_c is selected from heteroaryl, heterocyclic ring, lower alkyl, hydroxyalkyl, and arylheterocyclic ring;

D is selected from (i) -NO; (ii) $-NO_2$; (iii) $-C(R_d)-O-C(O)-Y-Z-[C(R_e)(R_f)]_p-T-Q$ in which R_d is hydrogen, lower alkyl, cycloalkyl, aryl, alkylaryl, aryl or heteroaryl, Y is oxygen, sulfur, or NR_i in which R_i is hydrogen, lower alkyl, R_e and R_f are independently selected from hydrogen, lower alkyl, cycloalkyl, aryl, heteroaryl, arylalkyl, amino, alkylamino, amido, alkylamido, dialkylamino, carboxy, or taken together are carbonyl, cycloalkyl or bridged cycloalkyl, p is an integer from 1 to 6, T is a covalent bond, oxygen, sulfur or nitrogen, Z is selected from a covalent bond, alkyl, cycloalkyl, aryl, heteroaryl, arylalkyl or arylheterocyclic ring, and Q is selected from -NO or $-NO_2$; (iv) $-C(O)-T^1-Z-[C(R_e)(R_f)]_p-T^2-Q$ wherein T^1 and T^2 are independently selected from T and R_e, R_f, p, Q, Z, and T are as defined above; (v) $-C(O)-T[C(R_y)(R_z)]_p$ wherein R_y and R_z are independently selected from $-T^1-[C(R_e)(R_f)]_p-G-[C(R_e)(R_f)]_p-T^2-Q$ wherein G is (*i*) a covalent bond; (*ii*) -T-C(O)-; (*iii*) -C(O)-T, or (*iv*) Y, and wherein R_d, R_e, R_f, p, Q, T, and Y are as defined above;

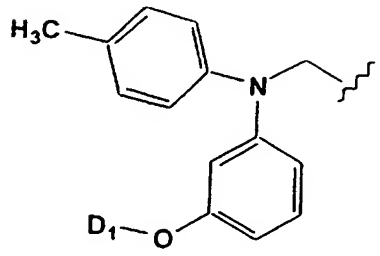
(ii) compounds having the structure:



II.

wherein, R_g is selected from:

(i)



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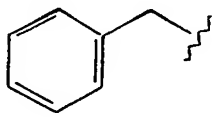
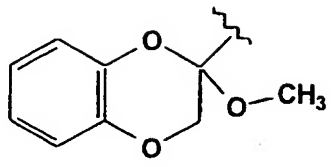
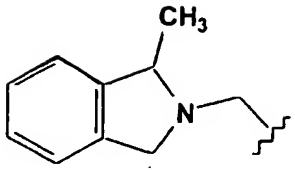
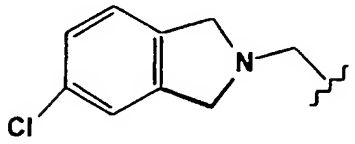
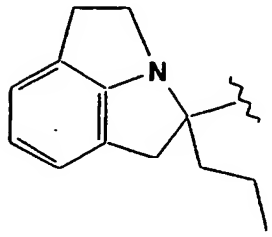


(iii) 

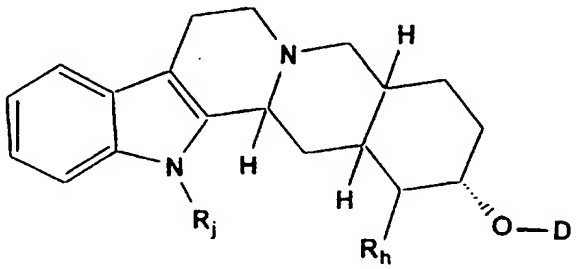
(iv) 

(v) 

(vi) 

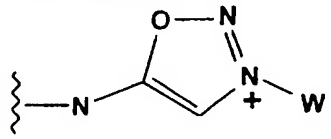
wherein D_1 is selected from hydrogen or D wherein D is as defined above and with the proviso that D_1 must be selected from D if there is no other D in the molecule:

(iii) compounds having the structure:



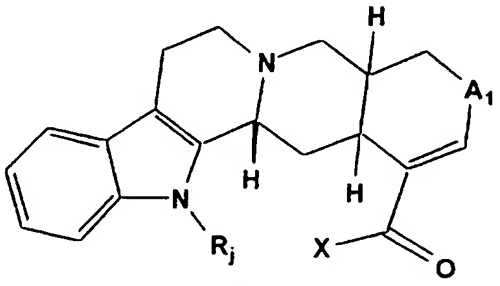
III.

wherein R_h is selected from hydrogen. -C(O)-OR_d or -C(O)-X wherein X is (1) -Y-[$C(R_e)(R_f)$]$_p$-G_i-[$C(R_e)(R_f)$]$_p$-T-Q: wherein G_i is (i) a covalent bond; (ii) -T-C(O)-; (iii) -C(O)-T; (iv) -C(Y-C(O)-R_m)- wherein R_m is heteroaryl or heterocyclic ring; and in which Y . R_d. R_e. R_f. p, Q and T are as defined above; or (2)



in which W is a heterocyclic ring or $NR_iR'_i$ wherein R_i and R'_i are independently selected from lower alkyl, aryl or alkenyl; and wherein Rj is selected from -D or $-(O)CR_d$ wherein D and R_d are as defined above:

(iv) compounds having the structure:

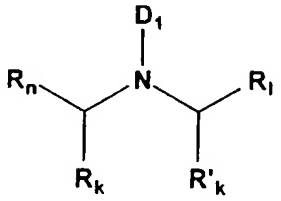


IV.

wherein,

A_1 is oxygen or methylene and X and R_j are as defined above;

(v) compounds having the structure:

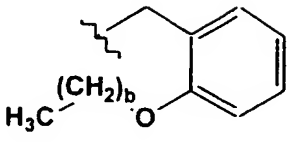


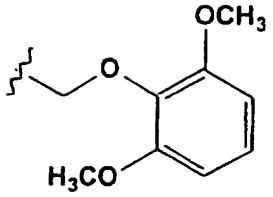
V.

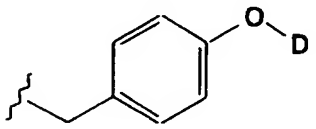
wherein

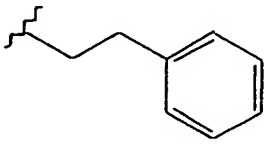
R_k and R'_k are independently selected from hydrogen or lower alkyl;

and R_1 is selected from:

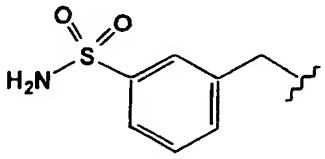
(i) 

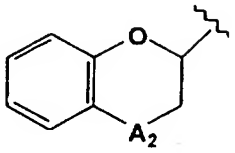
(iii) 

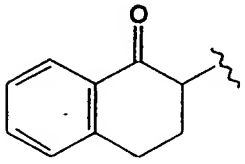
(ii) 

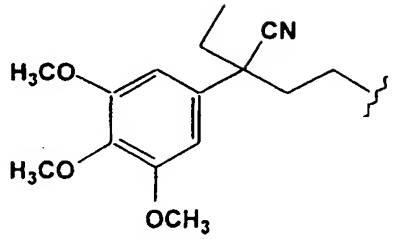
(iv) 

wherein b is an integer of 0 or 1; D_1 is as defined above; and
R_n is selected from:

(i) 

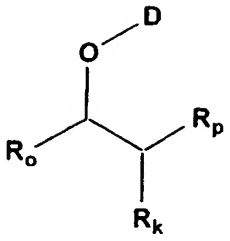
(iii) 

(ii) 

(iv) 

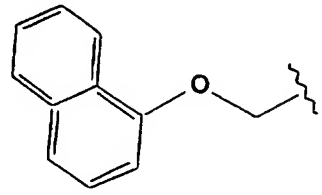
wherein A_2 is oxygen or sulfur;

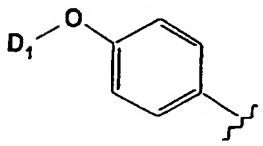
(vi) compounds having the structure:

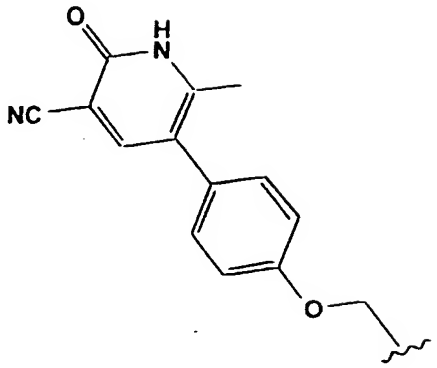


VI.

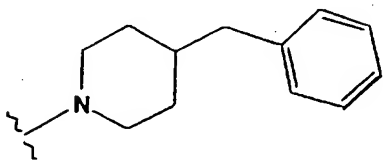
wherein R_o is selected from:

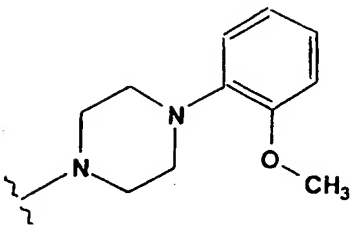
(i) 

(ii) 

(iii) 

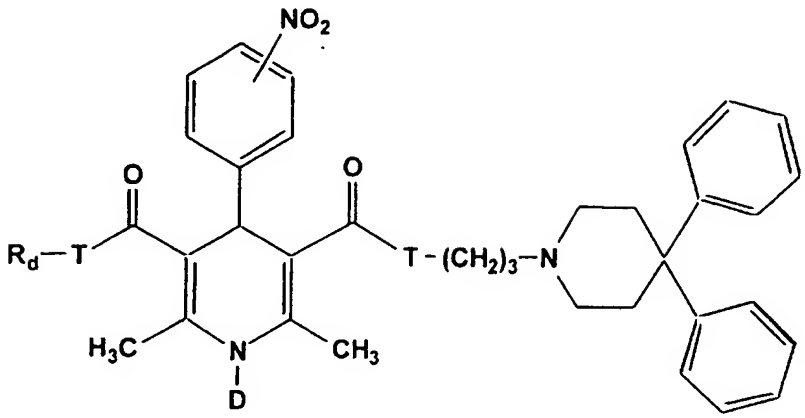
and R_p is selected from:

(i) 

(ii) 

and R_k. D and D_1 are as defined above;

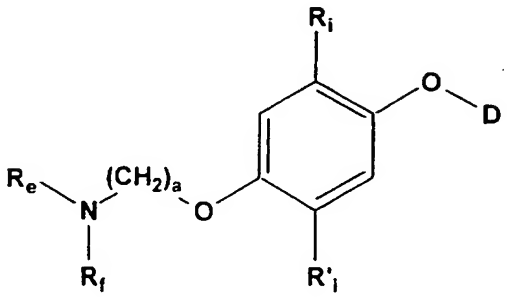
(vii) compounds having the structure:



VII.

wherein R_d, T and D are defined as above; and

(viii) compounds having the structure:



VIII.

wherein a, R_i, R'_i, R_e, R_f, and D are defined as above.

14. The composition of claim 11 wherein the α–adrenergic receptor antagonist is selected from the group consisting of haloalkylamines, imidazolines, quinazolines, indole derivatives, phenoxypropanolamines, alcohols, alkaloids, amines, piperazines and piperidines.

15. The composition of claim 14 wherein the haloalkylamine is selected from the group consisting of phenoxybenzamine and dibenamine; the imidazoline is selected from the group consisting of phentolamine, tolazoline, idazoxan, deriglidole, RX 821002, BRL 44408 and BRL 44409; the quinazoline is selected from the group consisting of prazosine, terazosin, doxazosin, alfuzosin, bunazosin, ketanserin, trimazosin and abanoquil; the indole derivative is selected from the group consisting of carvedilol and BAM 1303; the alcohol is selected from the group consisting of labetalol and ifenprodil; the alkaloid is selected from the group consisting of ergotoxine, ergocornine, ergocristine, ergocryptine, rauwolscine, corynathine, raubascine, tetrahydroalstonine, apoyohimbine, akuammigine, ß-yohimbine, yohimbol, pseudoyohimbine and epi-3α-yohimbine; the amine is selected from the group consisting of tamsulosin, beoxathian, atipamezole, chlorpromazine, phenothiazine, BE 2254, WB 4101 and HU-723; the piperizine is selected from the group consisting of naftopil and saterinone; and the piperidine is haloperidol.

16. The composition of claim 11 wherein the compound that donates, transfers or releases nitric oxide is a S-nitrosothiol.

17. The composition of claim 16 wherein the S-nitrosothiol is selected from the group consisting of those having the structures:

(i) $CH_3[C(R_e)(R_f)]_xSNO$;
(ii) $HS[C(R_e)(R_f)]_xSNO$:
(iii) $ONS[C(R_e)(R_f)]_xB$: and
(iv) $H_2N\text{-}(CO_2H)\text{-}(CH_2)_x\text{-}C(O)NH\text{-}C(CH_2SNO)\text{-}C(O)NH\text{-}CH_2\text{-}CO_2H$

wherein x equals 2 to 20; R_e and R_f are independently selected from hydrogen, lower alkyl, cycloalkyl, aryl, hereroaryl, arylalkyl, alkylamino, dialkylamino or taken together are carbonyl, cycloalkyl or bridged cycloalkyl; and B is selected from the group consisting of fluoro, alkoxy, cyano, carboxamido, cycloalkyl, arylkoxy, alkylsulfinyl, arylthio, alkylamino, dialkylamino, hydroxy, carbamoyl, N-alkylcarbamoyl, N,N-dialkylcarbamoyl, amino, hydroxyl, carboxyl, hydrogen, nitro and aryl.

18. The composition of claim 16 wherein the compound that donates, transfers or releases nitric oxide is selected from the group consisting of:

(i) compounds that include at least one ON-O-, ON-N- or ON-C- group;

(ii) a N-oxo-N-nitrosoamine which has an R_1R_2-N(O-M^+)-NO group wherein R_1 and R_2 include polypeptides, amino acids, sugars, modified and unmodified oligonucleotides, hydrocarbons where the hydrocarbon can be a branched or unbranched, and saturated or unsaturated aliphatic hydrocarbon or an aromatic hydrocarbon, hydrocarbons having one or more substituent groups and heterocyclic compounds; and

(iii) a thionitrate which has the structure R_{10}-S-NO_2 wherein R_{10} includes polypeptides, amino acids, sugars, modified and unmodified oligonucleotides, and a hydrocarbon where the hydrocarbon can be a branched or unbranched, and saturated or unsaturated aliphatic hydrocarbon or an aromatic hydrocarbon; and

(iv) a nitrate which has the structure R_{10}-O-NO_2 wherein R_{10} is as defined above.

19. 2-acyl-17α (3-methyl-3-nitrosothiolbutoxy) yohimban-16α–carboxylic acid C_1-C_4 alkyl ester and acid addition salts thereof.

20. 4-[2-(dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-(3-S-nitroso-3-methyl-butyric acid) ester and acid addition salts thereof.

21. A method of treating human impotence in an individual in need thereof which comprises treating an individual for human impotence by administering to the individual a therapeutically effective amount of a composition comprising a nitrosated or nitrosylated α–antagonist of the invention in a pharmaceutically acceptable carrier.

22. A method of treating human impotence in an individual in need thereof which comprises treating an individual for human impotence by administering to the individual a therapeutically effective amount of a composition comprising an α–adrenergic receptor antagonist, which can optionally be substituted with at least one NO or NO_2 moiety, and a compound that donates, transfers or releases nitric oxide in a pharmaceutically acceptable carrier.

Figure 1

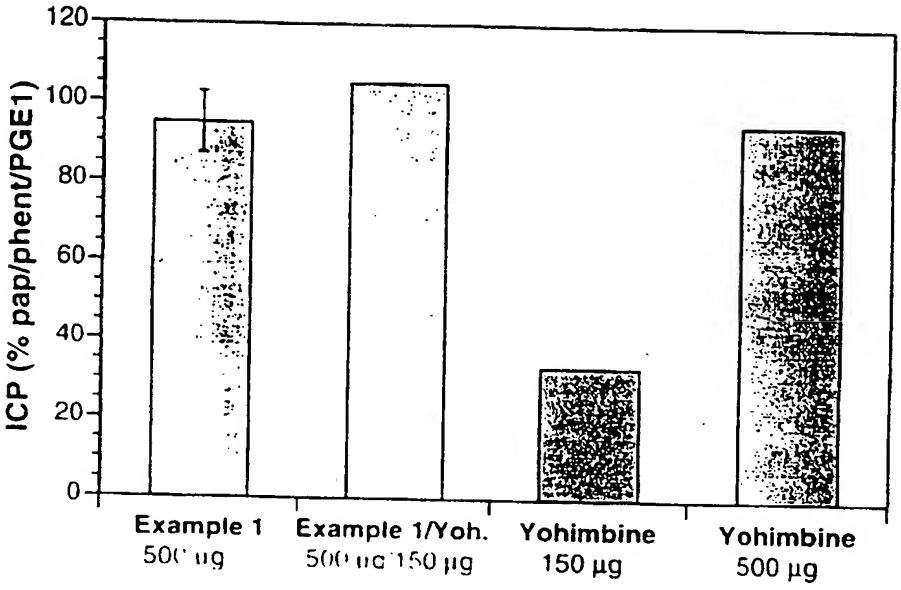

ICP (% pap/phent/PGE1)
120
100
80
60
40
20
0
Example 1
500 µg
Example 1/Yoh.
500 µg 150 µg
Yohimbine
150 µg
Yohimbine
500 µg

Figure 2

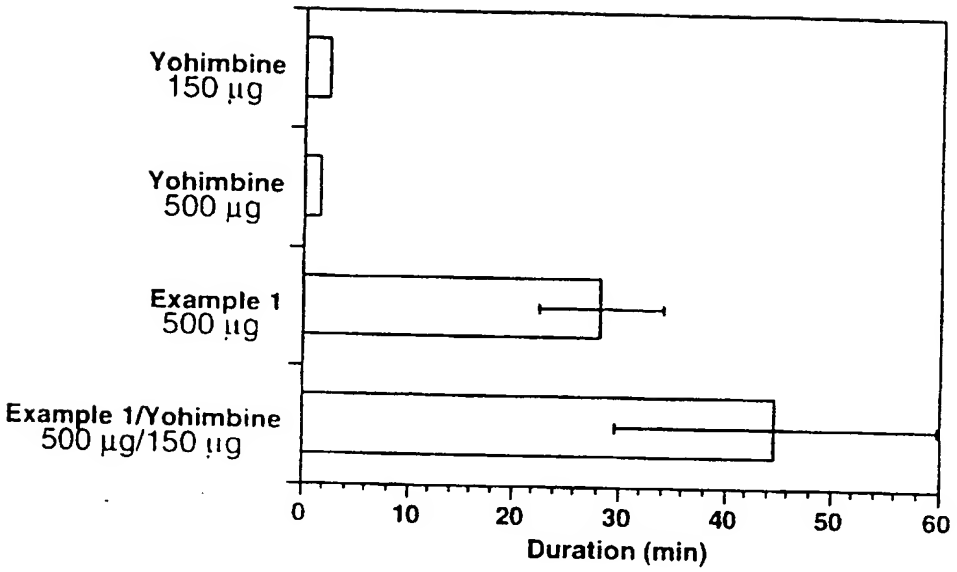

Yohimbine
150 µg
Yohimbine
500 µg
Example 1
500 µg
Example 1/Yohimbine
500 µg/150 µg
0
10
20
30
40
50
60
Duration (min)

Figure 3

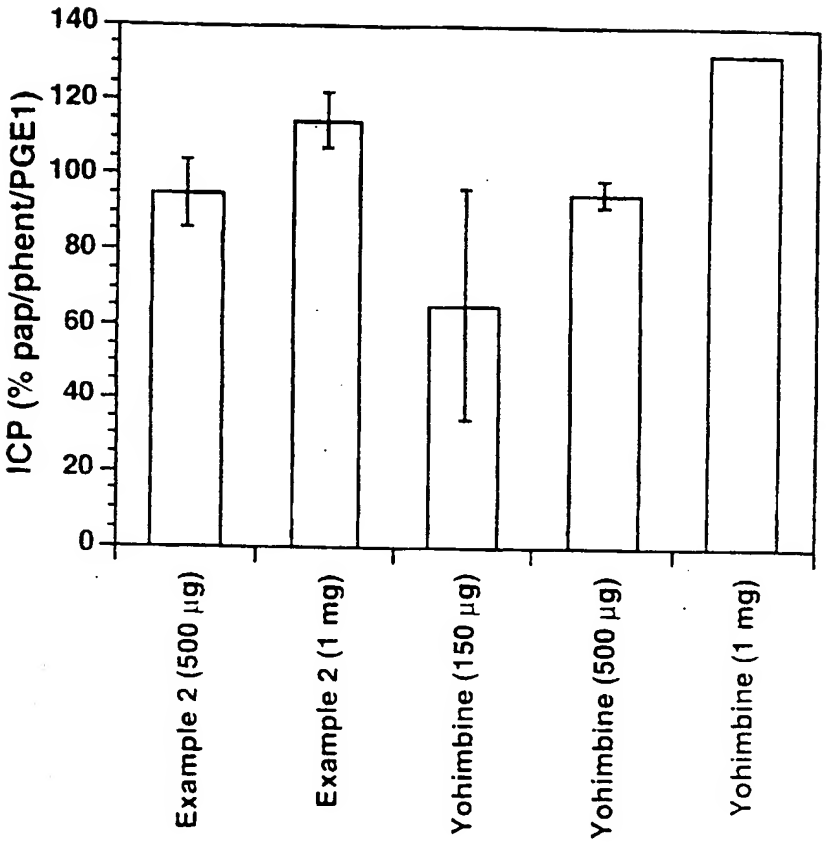

ICP (% pap/phent/PGE1)
140
120
100
80
60
40
20
0
Example 2 (500 µg)
Example 2 (1 mg)
Yohimbine (150 µg)
Yohimbine (500 µg)
Yohimbine (1 mg)

Figure 4

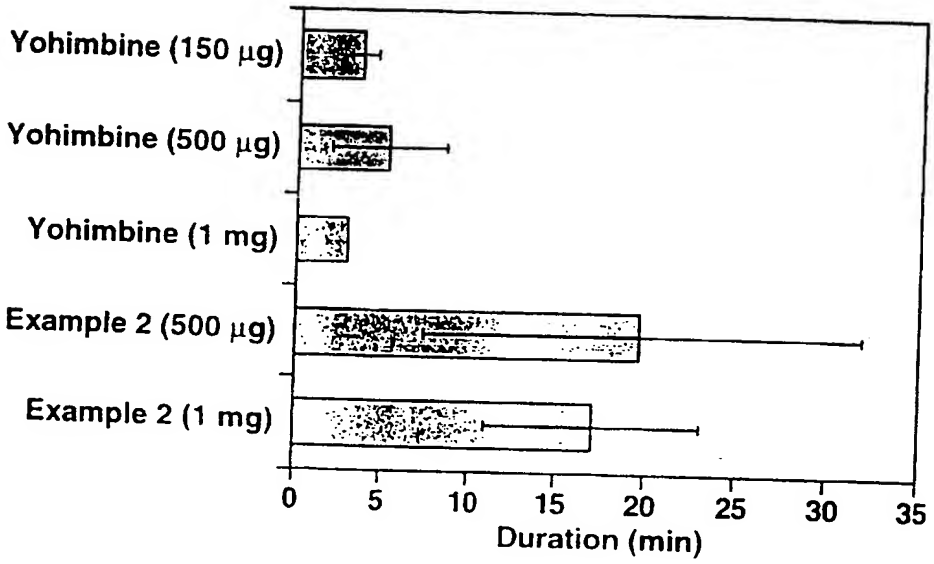

Yohimbine (150 µg)
Yohimbine (500 µg)
Yohimbine (1 mg)
Example 2 (500 µg)
Example 2 (1 mg)
0
5
10
15
20
25
30
35
Duration (min)

Figure 5

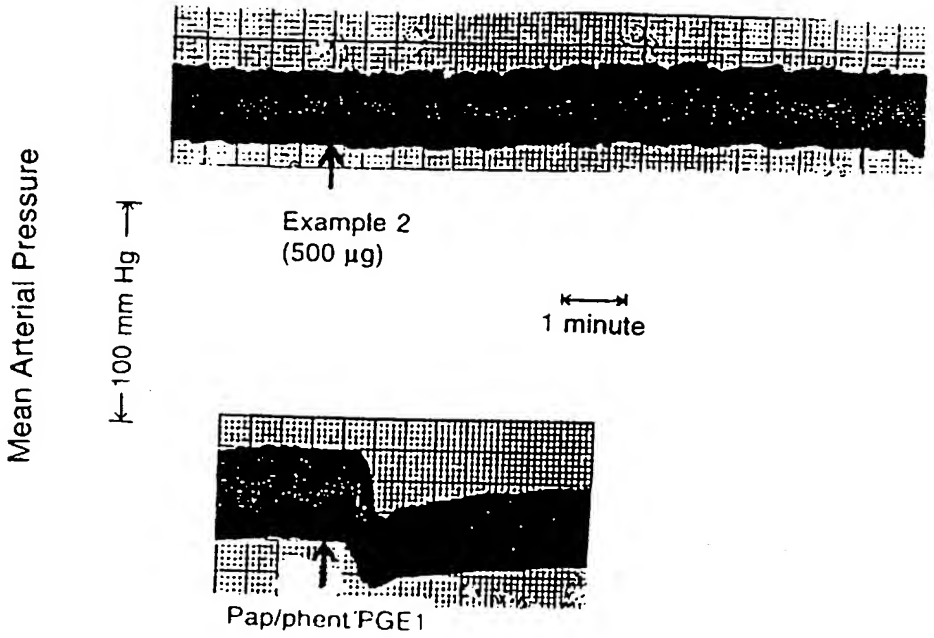

Mean Arterial Pressure
100 mm Hg
Example 2
(500 µg)
1 minute
Pap/phent/PGE1

Figure 6

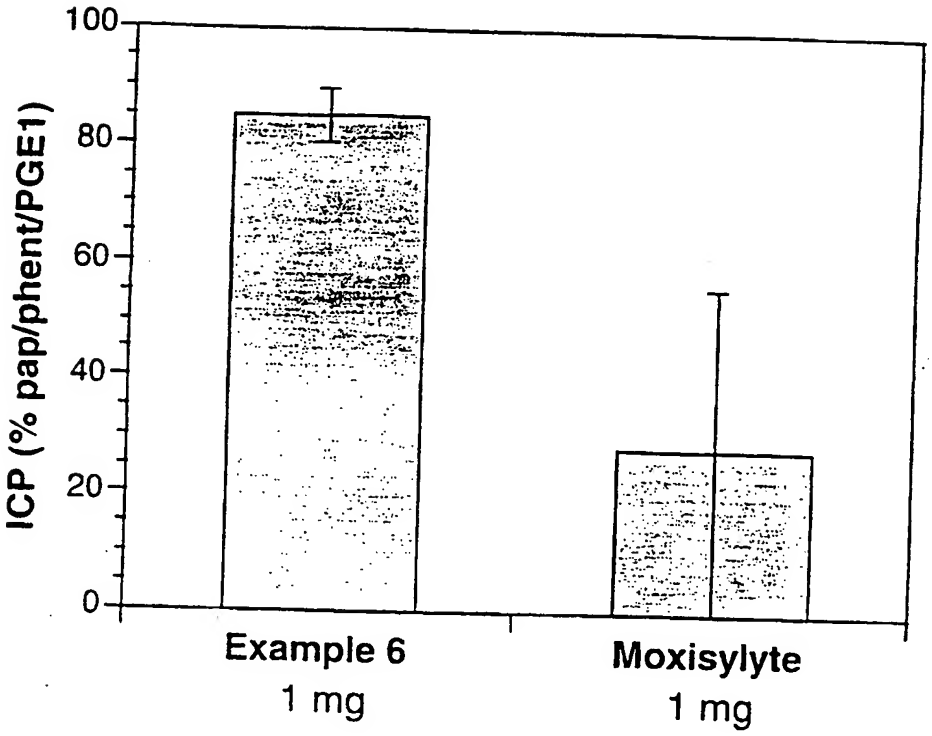
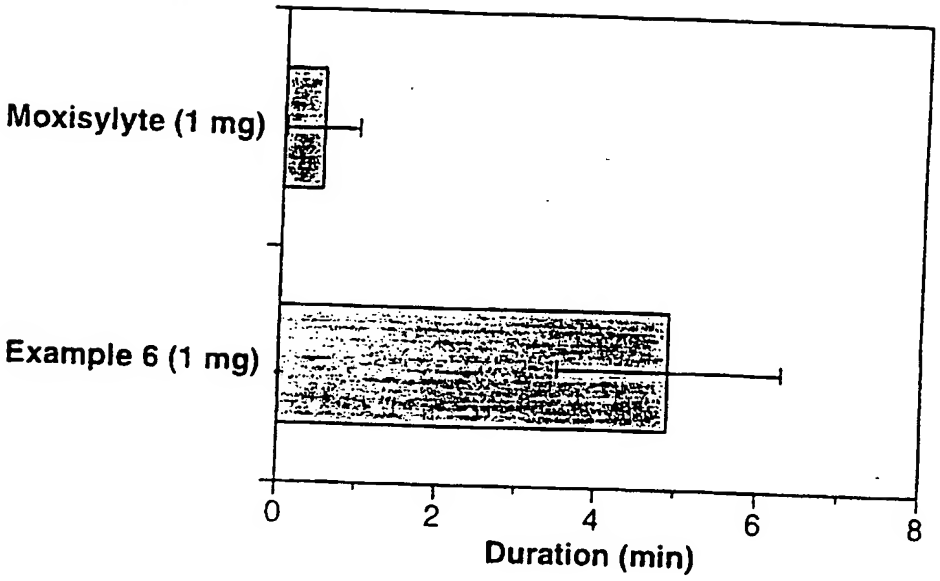

100
80
60
40
20
0
ICP (% pap/phent/PGE1)
Example 6
1 mg
Moxisylyte
1 mg

Figure 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/01294

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :A01N 43/58, 43/60; C07D 403/00
US CL :514/252, 255, 929; 544/358-359; 564/33
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 514/252, 255, 929; 544/358-359; 564/33

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, CAS ONLINE, MEDLINE, BIOSIS, WPIDS, EMBASE
search terms: applicants names, impot?, erect?, peni?, or cavernosum?,

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,236,904 A (GERSTENBERG et al.) 17 August 1993, see entire document.	1, 2, 11-13, 16-18, 21
A	US 5,474,535 A (PLACE et al.) 12 December 1995, see entire document.	1, 2, 11-13, 16-18, 21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 28 APRIL 1997	Date of mailing of the international search report 22 MAY 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer IW for BENNETT CELSA Telephone No. (703) 308-0196

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/01294

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1,2, 11-13, 16-18, 21: species A

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/01294

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

UNITY OF INVENTION

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT RULE 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1, 2, 11-13, 16-18 and 21 drawn to a nitrosated/nitrosylated alpha-adrenergic receptor antagonist compound and composition and a first method for treating impotence using a composition comprising an antagonist of :

species A of structure I ;

species B of Structure II;

species C of Structure III;

species D of Structure IV;

species E of Structure V;

species F of Structure VI;

species G of Structure VII;

species H of Structure VIII;

Group II: claims 3-10 and 14-15 drawn to compositions comprising an alpha adreneric compound of:

species A haloalkylamine;

species B imidazoline

species C quinazoline

species D indole derivative

species E phenoxypropanolamine

species F alcohol

species G alkaloid

specis H amine

species I piperazine

species J piperidine

species K amide

species L piperizine

Group IIII: claim 19 drawn to 2-acyl-17 alpha(3-methyl-3-nitrosothiolbutoxy) yohimban-16alpha- carboxylic acid and derivatives thereof.

INTERNATIONAL SEARCH REPORT

In.. national application No.
PCT/US97/01294

Group IV: claim 20 drawn to 4-[2-(dimethylamino)ethoxy]-2-methyl-5-(1-methylethyl)phenol-(3-nitroso-3-methyl-butyric acid) and derivatives thereof.

Group V: claim 22 drawn to a second method for treating impotence comprising the use of an optionally substituted alpha adrenergic receptor antagonist and a nitric oxide donor compound;

Claims to different categories of invention will be considered to have unity of invention if the claims are drawn to a product, and a process of use of said product (37 C.F.R. § 1.475(b)(2)). Accordingly, the claims of Group I directed to a product, a composition and its first use possess unity of invention. Group II drawn to a composition; Groups III and IV drawn to different chemical compounds and Group V drawn to a second method are all directed to additional categories of invention which are not linked by a special technical feature so as to form a single general inventive concept as required by 37 C.F.R. § 1.475(a) and PCT Rule 13. Additionally, unity of invention is lacking between the groups since there is no technical relationship between the various solutions to the problem since compounds useful for treatment of impotence are known in the art (e.g. papaverine). With respect to the separate alpha adrenergic antagonist compound species of the Markush groups within Groups I to V, unity of invention is lacking for each compound species and each respective Markush group since the alternatives lack a common activity and particularly fail to possess a common structural element.